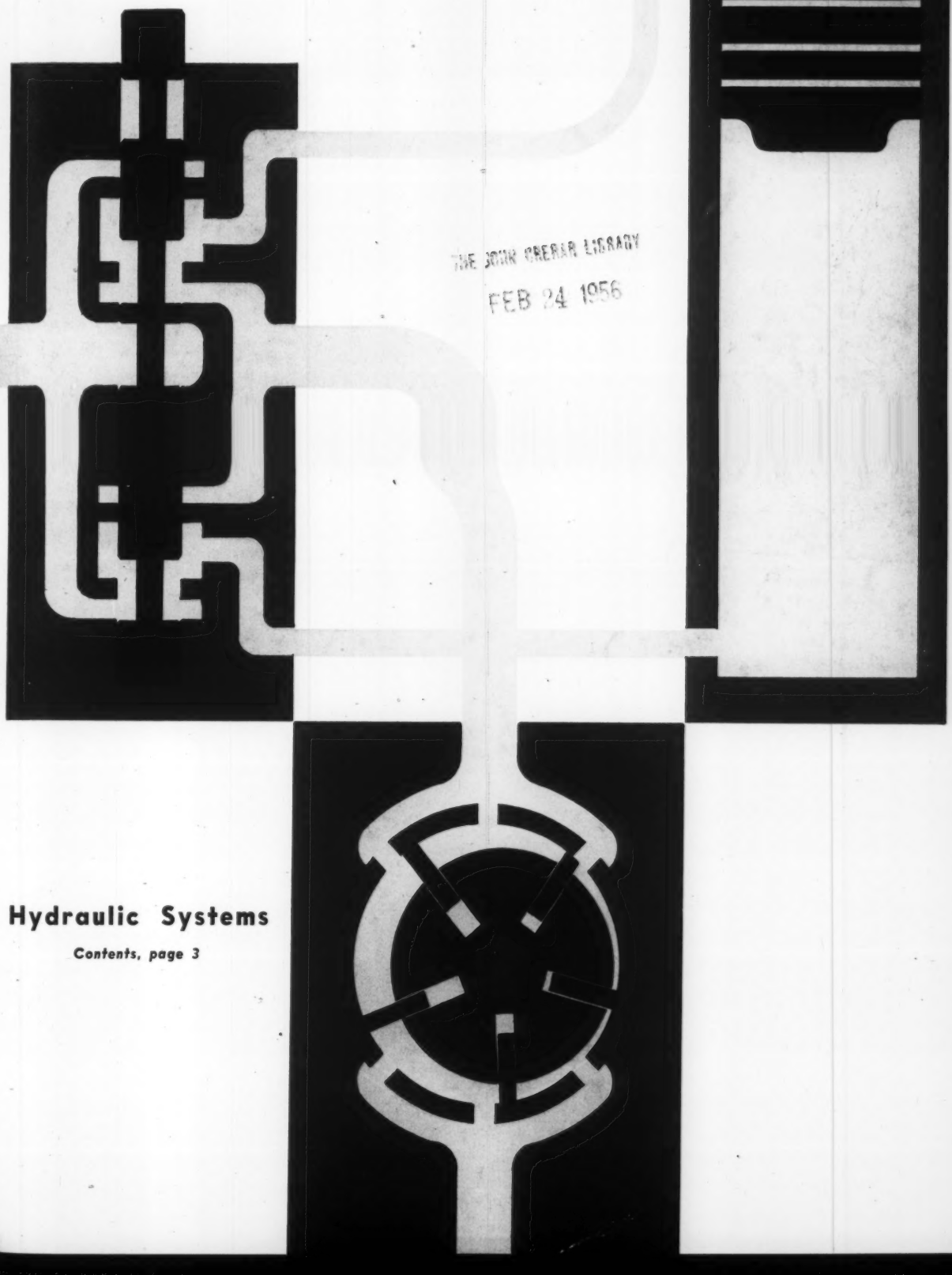
FEBRUARY 23, 1956

EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



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Hydraulic Systems

Contents, page 3

FLEXIBLE SHAFT IDEAS for ENGINEERS

Difficult alignment problems easily solved with flexible shafts

THE ADAPTABILITY of a flexible shaft to almost any operating position makes it an extremely useful means of correcting misalignment difficulties.

In the application shown, for instance, a power drive flexible shaft is incorporated into the drive of a gear pump. Its use here permits adjustment of the pump shaft drive pulley when it becomes necessary to regulate the tension of the V-belt driving the pulley.

How to pick the right flexible shaft

ONE SURE WAY *of getting the right flexible shaft for your needs is to rely on the advice of S.S.White engineers. Their long experience with the problems involved will assure you of sound answers. They know which type shafting will work best under your given set of conditions. It costs nothing to take advantage of this service. It will save you plenty of time and money.*

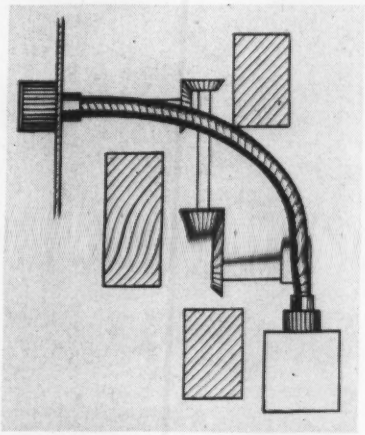
One part does the work of many when you use a flexible shaft

Design simplification is one of the reasons why it pays to use S.S.White "Metal Muscles"®

IT'S A DESIGNER'S AXIOM that simplification is one of the most effective ways of reducing product costs. By so doing, you save weight, you eliminate a number of unnecessary parts and you reduce assembly time and costs.

Eliminating Parts

When it's a question of transmitting rotary power or providing remote control, especially where turns or alignment are involved, an S.S. White flexible shaft is an efficient cost-saving solution. The illustration below demonstrates why this is so.



One flexible shaft is all it takes to do a job that might otherwise require an entire system of bevel gears, straight shafts, universals, etc. Added to this is the fact that installation is greatly simplified and alignment problems are eliminated.

90% Cost Reduction

Actual cost figures on a control set-up for a large dual hydraulic power system dramatize how effectively flexible shaft simplification can cut costs.

In this case, 35 parts including universal rods and bevel geared elbows were being used to transmit control from two handwheels to a motor control unit and thence to two hydraulic motors.

Without any necessity of redesigning the equipment, 4 standard S.S.White flexible shafts were used in place of the original control system. The result was a 90% savings – and, incidentally, 100% improved performance.

What About Your Application?

Perhaps your own designs cannot realize benefits as outstanding as this. But the chances are good indeed, that, if you are not now using them, you'll be able to handle many remote control and power drive applications better and at less cost with an S.S.White flexible shaft.

USEFUL FLEXIBLE SHAFT DATA

Bulletin 5601 has concise information on how to select and apply flexible shafts. Send for a copy.

F5-2

S.S.White

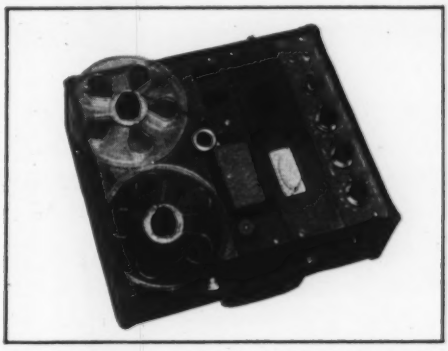
FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

XUM

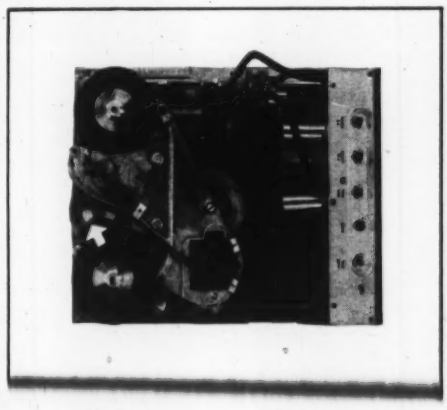
Why Bodine motors were selected for Ampex Tape Recorders



1 This is a new portable 28-pound Ampex 600 professional tape recorder. It is ideal for broadcast studios and music schools.

2 Studio engineers use the Ampex 600 for broadcast recording, line recording, dubbing and editing, and broadcast playback.

3 The frequency response of the Ampex 600 is 40 to 15,000 cps; signal-to-noise ratio is over 55 db.; flutter and wow under 0.25%.



4 Supplying power for the capstan drive, plus take-up and rewind operations, is a Bodine Type KYC-41, capacitor, synchronous motor

5 Meet Mr. John Leslie, Chief Engineer, Audio Division, Ampex Corp., Redwood City, Calif., manufacturers of Ampex tape recorders.

"Bodine motors have proven themselves over a period of years to be excellent as to both reliability and performance. Bodine's quality of workmanship provides us with smooth running, trouble-free motors whose torque characteristics are uniform from motor to motor."

6 Mr. Leslie relates why Bodine motors were selected to meet his company's very exacting requirements...see above.

50th Anniversary

BODINE

fractional horsepower

MOTORS

7 Be sure your motor is as good as your product. For information contact Bodine Electric Co., 2258 West Ohio Street, Chicago, Illinois.

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS FOR:

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sanders
vending machines
exhaust fans
duplicating machines
portable tools
sound recorders
air conditioners
check protectors
respirators
voltage regulators
x-ray timers
traffic signal timers
stirrers
calculating machines
envelope sealers
diesel governors

. . . and for many other applications.

Ask for a sample copy of "The Motorgram," a bi-monthly publication discussing application and design of fractional horsepower electric motors.

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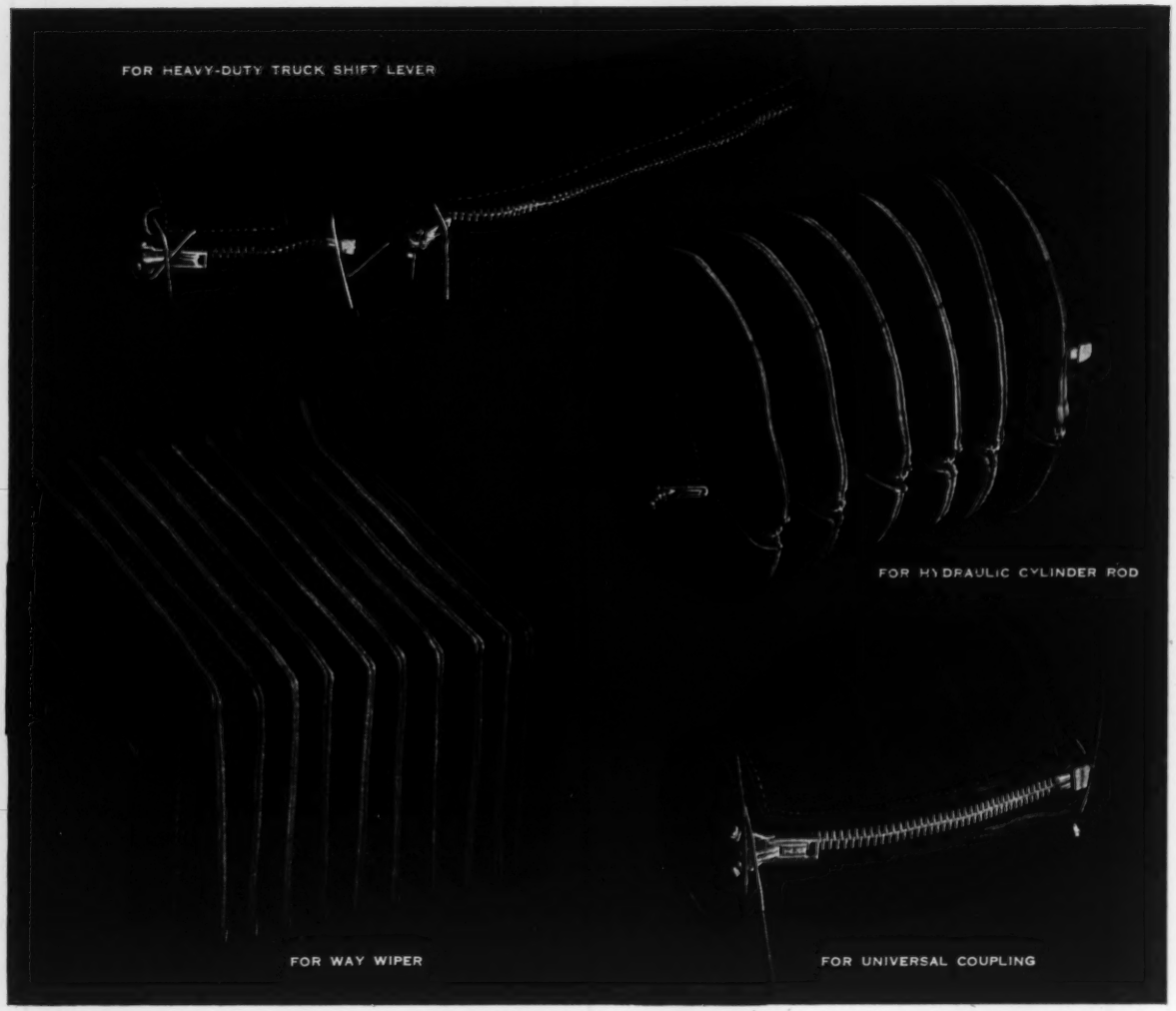

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C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • C/R Non-metallic Gears

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

February 23, 1956
Volume 28—No. 4

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—ITEM 156—
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Engineering News Roundup

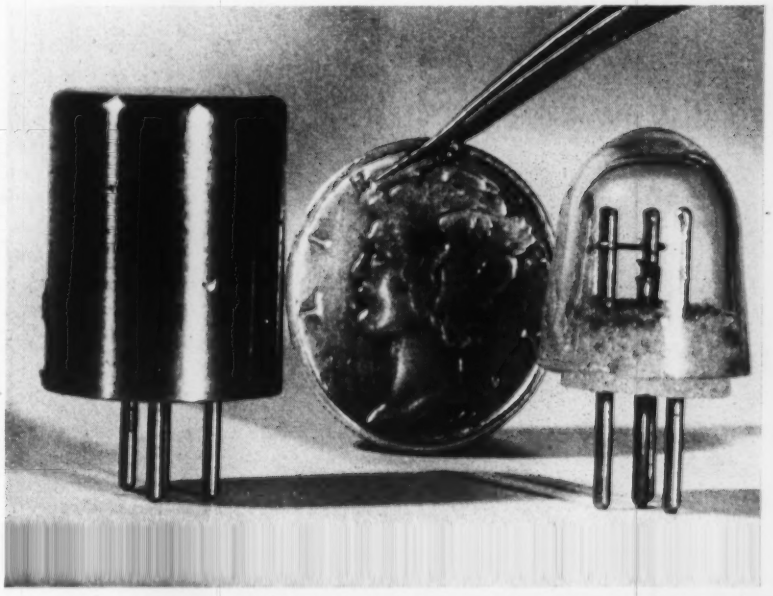
Dime-Size Transistor Increases Frequency Range

Performance Credited To Fabrication Technique

NEW YORK — Unsurpassed performance at very high frequencies is claimed for a new transistor developed by the Bell Telephone Laboratories. The new transistor is expected to be used in many applications where transistors previously have been unsuitable.

Performance of transistors is measured in two principal ways. One is the number of oscillations or self-generated electrical pulses per second. The second is the number of voice or communication channels that can be amplified. In the latter category, Bell scientists report the new transistor unequaled. Experimental units of the new transistor have amplified currents across a 20,000,000 cycle wide band by 100 to 1.

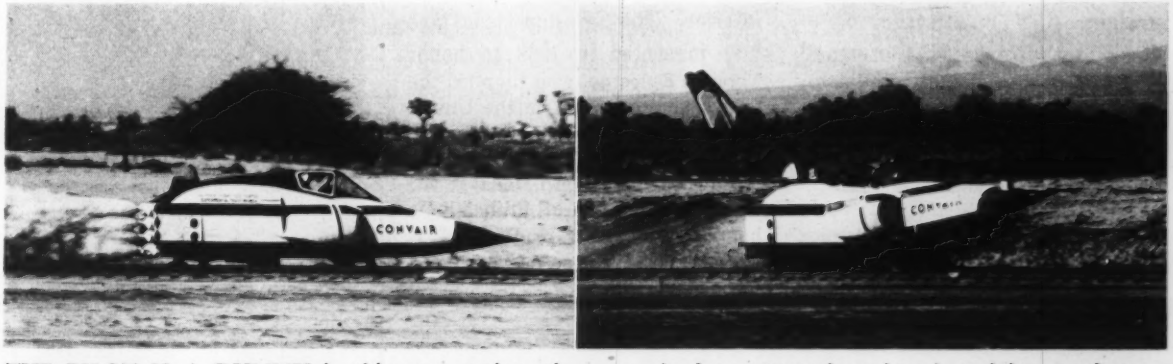
Success of the new transistor is reported due to new fabricating techniques which control chemical layers as thin as 50 millionths of an inch. The new techniques employ the chemical process of diffusion by which minute amounts of impurities are introduced in controlled amounts into a material.



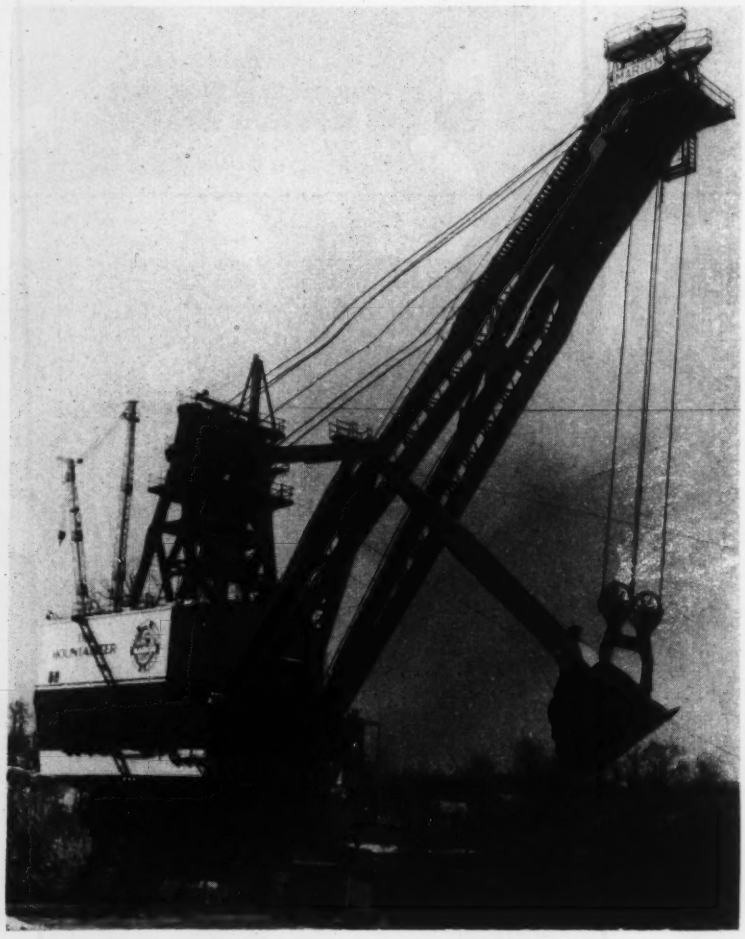
Silicon and germanium laboratory models of a new transistor announced by Bell Telephone Laboratories. Compared for size with U. S. dime, silicon transistor with brass cap is at left and germanium transistor is at right

The transistor consists of a three-layer chemical "sandwich." The center layer is known as the "base." The other two are the emitter and collector layers. The narrower the base layer can be made, the higher the frequency at which it will operate. Diffusion provides control of these microscopic dimensions.

In practical application of transistors, a basic consideration is "frequency cut off." This is the frequency point up to which there is



THE PILOT IS A DUMMY in this nose section of the Convair F-102A all-weather jet interceptor. These are frames from film which record events during tests of pilot ejection apparatus. Under rocket thrust, sled streaks down 10,000 feet of track attaining speeds more than 750 mph. A six-foot 200-lb anthropomorphic dummy made of rubber and metal registers the effects that half-second ejection would have on human pilots



WORLD'S LARGEST SHOVEL, called "Mountaineer", has been completed recently by Marion Power Shovel Co. for Hanna Coal Co. To be used in strip mining, Mountaineer will remove earth to average depth of 90 ft. Bucket capacity is 60 cu yd, enough to fill a room 10 x 20 x 8 ft. Dipper handle is 92 ft long, boom is 150 ft., and overall shovel height is 160 ft. Shovel moves on eight crawlers each bigger than an ordinary auto. Three-passenger elevator operates inside 6-ft diameter center pin. Sixteen electric motors supply 12,000 hp to operate the shovel. Motors include the largest mill-type, both horizontal and vertical, ever made in this country

straight, full amplification of a signal and after which the signal is amplified with steadily diminishing strength. The new transistors have been found to reach a cut off between 500 and 600 megacycles.

For "distinguished engineering achievement" Columbia University has named Felix E. Wormser, Assistant Secretary of the Interior, to receive the Egleston Medal for 1956. Mr. Wormser had been a vice president of the St. Joseph Lead Co. and president of the Lead Industries Assn. prior to his appointment to the Department of Interior. The Egleston Medal was first presented in 1939 to honor Thomas Egleston, who founded the first school of mines in the United States at Columbia in 1864.

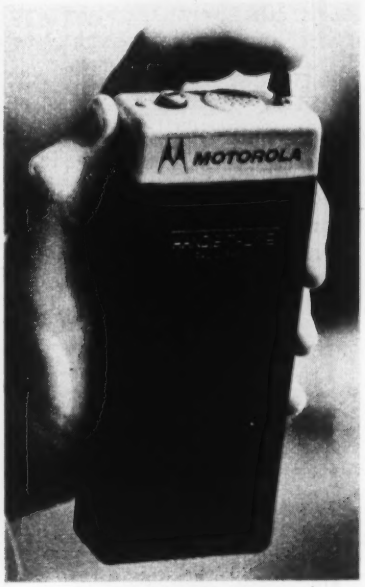
Edward Longstreth Medal of the Franklin Institute of Philadelphia has been awarded to Richard Y. Case, chief engineer, power transmission department, United States Rubber Co., for inventing the timing belt, considered the most outstanding advance in power transmission during the past 50 years. The medal is awarded for "inventions of high order and for particularly meritorious improvements and developments in machines and mechanical processes."

Transistor Radio Pager Makes Personal Calls

CHICAGO — Individual paging of personnel is now possible with a new pocket radio paging system announced by Motorola.

Claimed the first of its kind, the new Handie-Talkie low-frequency system consists of a selector console with individual buttons for key personnel, an FM transmitter that radiates alerting tones and voice messages within a confined induction loop area, and the individual transistor radio receivers themselves.

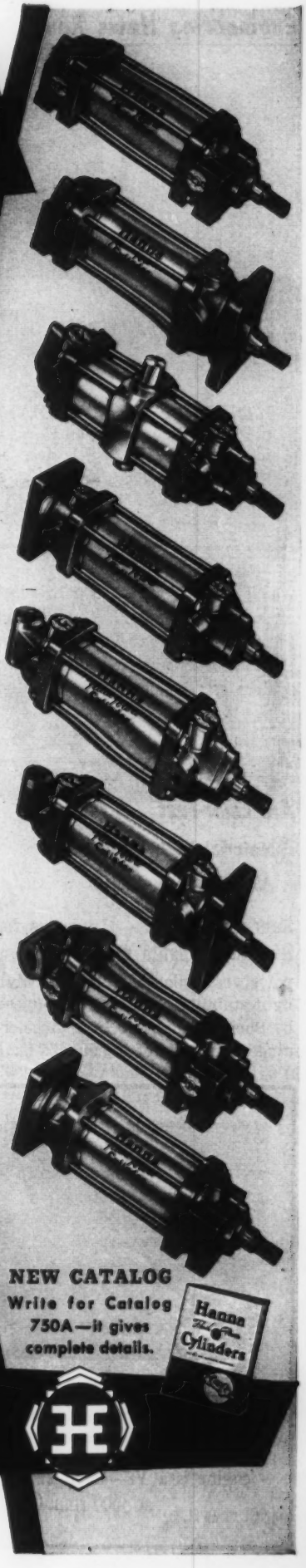
The portable receiver itself weighs 10 oz and is slightly larger than a pack of king-size cigarettes. The unit can be clipped in a pocket or worn on a belt, and is powered by a 4-volt mercury-cell battery. Its FM reception is immune to common types of interference generated by X-ray, diathermy and other noise-generating equipment



Front Cover

Three basic hydraulic mechanisms—a pump, valve and cylinder—make up a stylized hydraulic system on this issue's cover by George Farnsworth. These and other types of hydraulic components are discussed in the article by W. T. Stephens on which the cover is based.

Here's GREATER POWER for you ... in a MORE COMPACT DESIGN



FEATURES YOU WILL LIKE:

- Greater power from a more compact design.
- Resistance to corrosion throughout.
- Positive sealing with minimum friction loss.
- Materials selected for strength, durability and long cylinder life.
- Interchangeable heads and mountings.
- Conformation to J.I.C. Standards.
- Automatic compensation for rod packing wear.
- Built-in piston rod scraper to prevent dirt and abrasives from scoring rod or damaging packings.
- Adjustable cushions of unique design.
- Wide choice of operating pressures; Air to 250 psi; hydraulic to 750 psi.

The New HANNA T750 Series Fluid Power CYLINDERS

● You'll find some unique and very interesting operating features in these new Hanna **T750** Series Fluid Power Cylinders . . . features that will help you solve many of your cylinder application problems more easily and more simply. The new Hanna **T750** Series comes in a range of capacities, sizes and mounting styles—for air operation up to 250 psi and hydraulic operation up to 750 psi.

For details, ask your Hanna Representative (see your classified telephone directory), or write today for a copy of the new **T750** Fluid Power Cylinder Catalog. No obligation.

NEW CATALOG
Write for Catalog 750A—it gives complete details.

Hanna Engineering Works

1751 Elston Avenue, Chicago 22, Illinois

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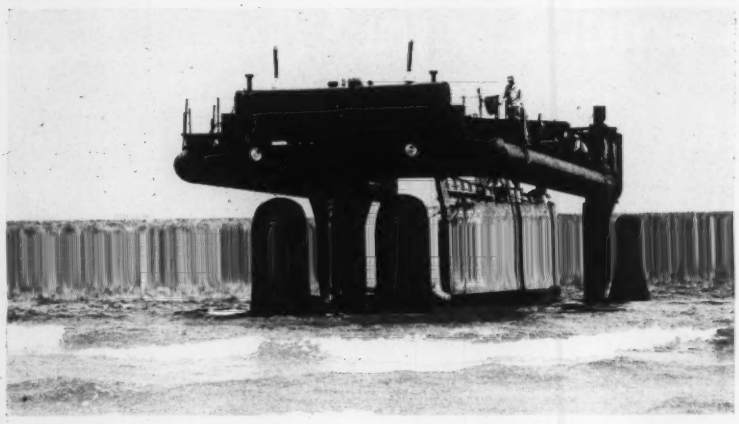


LANDING-CRAFT RETRIEVER is this vehicle recently developed for the Army Transportation Corps by R. G. LeTourneau Inc. Self-propelled, it operates in water 8 ft deep and can lift any craft up to 67 tons. Retriever is 75 ft long, 38 ft wide, 22 ft high. Wheels are driven individually by totally enclosed, waterproof, electric motors. Tubeless tires are 10 ft high, 4 ft wide. Eight floodlights illuminate night operations

which may be found in a hospital or industrial plant. Battery life is approximately four 40-hour weeks. Up to several hundred persons per system can be paged individually.

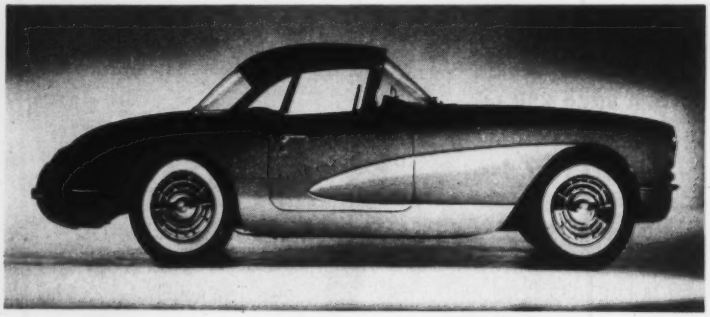
New Plastic Light Diffusers Are Color-Fast

Material In The Plastic Absorbs Ultra-Violet

SHEFFIELD, MASS. — Diffusers for fluorescent lights made of a new polystyrene plastic which has high light stability have been announced by Sheffield Plastics Inc. Accelerated aging tests of the shields have shown they will retain their initial color even after use for 60,000 lighting hours.

Designated UVR grade, the new diffusers obtain their stability through a special ultraviolet light absorbing material which has been permanently combined with the plastic on the side nearest the light source. New extrusion techniques have been developed to make this possible.

The process concentrates the ultraviolet absorbing material on the exposed side of the shield, thereby providing the shield maximum protection against discoloration caused by ultraviolet radiation emitted by fluorescent lights. Light stability of the new shields is achieved with-



1956 CORVETTE is this newest model of the Chevrolet specialty car. It features a restyled plastic body, a power-operated fabric top, choice of two transmissions and transistor radio. Alternate to the fabric top is removable solid top, made like the body panels. The engine is a V8—rated 225 hp at 5200 rpm and 270-lb ft torque at 3600 rpm. Compression ratio is 9.25 to 1

Topics

Automatic bed recently introduced converts from a sofa into a bed at the touch of a button. Completely safe, the bed will blow a fuse if the button is pushed while an occupant is in it. So will the occupant, no doubt.

• • •

Special sports car abbreviations used by the Baltimore Local of the Motor Sports Car Assn. include things like this: RPM—Repairs Per Month; MPH—Monthly Payments Heavy; FOB—Prices in French or British currency.

• • •

Bigger bumpers are what city drivers want, according to a survey made by General Motors at their recent Motorama in New York.

• • •

Volkswagen has abandoned plans to produce their small car in U. S. High production costs are said to have caused the change in plans.

• • •

Light amplifier capable of amplifying light up to 50,000 times is being produced commercially by Bendix Aviation. It will make possible X-ray inspection of engines in operation or detailed photographs of the canals on Mars. Ultimate goal of the engineers is an X-ray photograph of an engine in operation on a canal on Mars.

• • •

We've been elected to membership in the Society of the Plastics Industry. Through association with SPI, MD expects to increase coverage of the plastics field.

• • •

Speeds up to 10,000 mph will be studied by Brooklyn Polytech students in a recently completed aerodynamics laboratory.

• • •

Soft riding trucks will incorporate air suspension, now installed in busses. A road shock damper attached to the front wheels will also contribute to making the driver's life easier. These developments, announced by General Motors, are expected to improve safety by reducing driver fatigue.

Facing Page—Item 158→

Unitool*... *a fast, easy, low-cost way* to produce prototype bevel gears!

Now you can produce small quantities of spiral bevel, Zerol® bevel and hypoid gears with a comparatively small capital outlay and without specially trained personnel.

You can reduce the time and expense it takes to change your angular drive from a drawing board idea to a working model, too, because the Unitool Method produces good quality gears directly from the initial calculations.

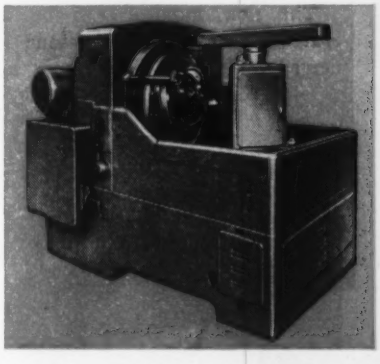
The Unitool Method is based on a fundamentally different theoretical approach to bevel gear generation. Only six different cutters are required to cut gears up to 18" pitch diameter—spiral bevel and Zerol bevel pairs of any ratio; hypoid pairs 3:1 ratio and higher. Because these cutters have a wide overlap in range, cutter diameter is not critical.

Calculations are short enough and easy enough for you to do in your own plant. Correct tooth thickness and position of contact are easily determined without requiring special operator training.

The Unitool Method is designed especially for the Gleason No. 106 and No. 116 Hypoid Generators which feature increased universal cutter tilt.

*Trademark

We will be glad to send further information on the Unitool Method and the two Gleason Generators best suited for it at your request.



The Gleason No. 106 Hypoid Generator is a high-speed machine for spiral bevel, Zerol bevel and hypoid gears up to 8½" pitch diameter. Its larger counterpart, the No. 116 Hypoid Generator, handles the same type gears up to 18" pitch diameter.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

out sacrifice of the initial color, light transmission, toughness or satin-smooth finish characteristics of regular shields.

Sheffield research leading to the new product disclosed that the discoloration of polystyrene plastic results from exposure to ultraviolet light, although relatively small amounts are transmitted through the glass envelope of fluorescent tubes. The ultraviolet reacts photo-chemically with the polystyrene material to cause discoloration.

Sheffield says the new material overcomes one of the biggest problems in the use of plastic fluorescent light shields.

Device Fights Fires Where Men Can't

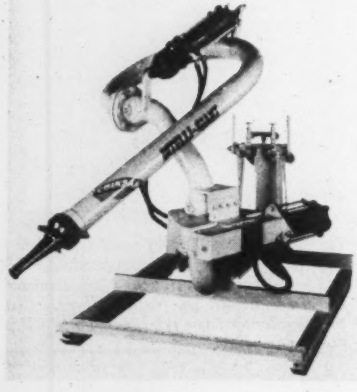
Mechanical Fireman Operates On Water Pressure

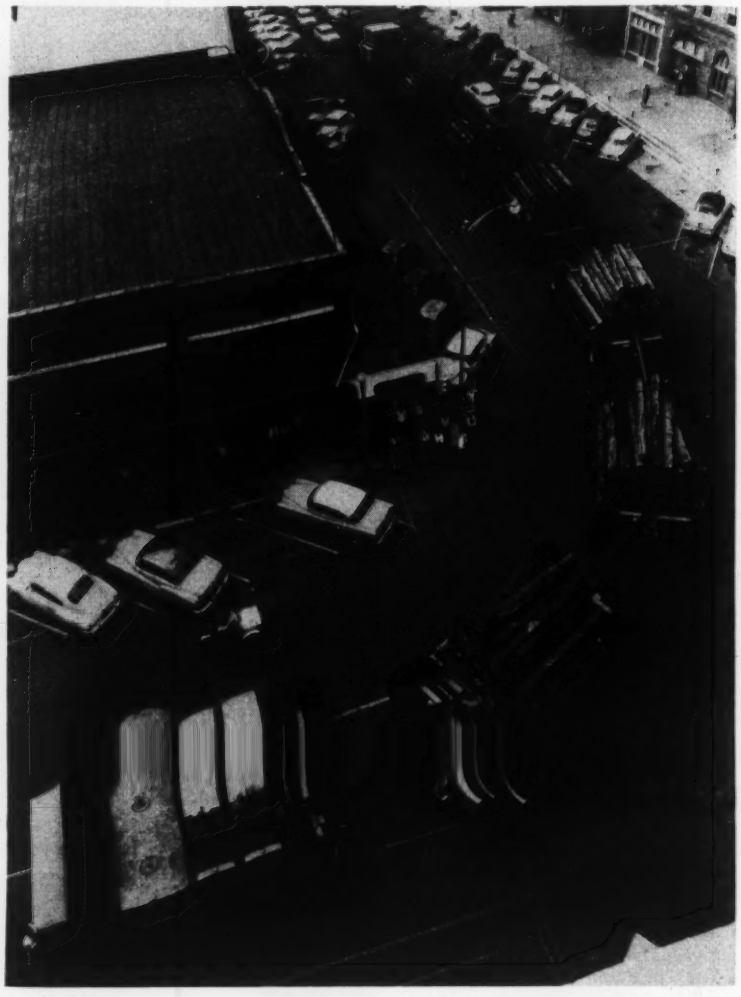
BREA, CALIF. — Fire departments have witnessed recent demonstrations of a new fire monitor that features ease of operation and versatility of service. The device is manufactured by Chiksan Co. and named the Intelli-Giant.

Through a 2½ in. tip, it discharges a stream of water at 2000 gpm to an effective range of 300 ft. Pressure range is 30 to 300 psi.

Intelli-Giant covers a horizontal pattern of 270 degrees and its vertical motion is 120 degrees. It is operated by hydraulic pistons with power from diverted water pressure.

The new monitor can be operated manually with pistons removed and can handle foam and chemicals. A 270-degree tube turn that constitutes the barrel serves to balance the device. Hydraulic controls may be removed to a safe distance from a fire for remote operation.





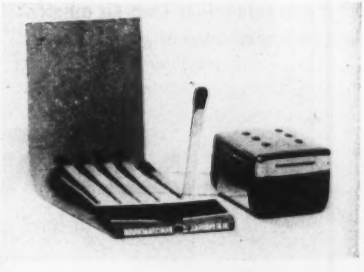
CROSS-COUNTRY FREIGHT TRAIN is this eight-car unit developed by R. G. LeTourneau Inc. Similar vehicles were delivered recently to Army Transportation Corps. All wheels on every car are driven individually by electric motors. Tires are 10 ft tall, 4 ft wide, have as little as 5 psi pressure. Steering mechanisms assure all cars make turns at the same spot. The train is claimed to be a better hill-climber than an ordinary automobile

---

"Design for Profit" is the theme for the 13th annual Machine Design Conference scheduled at the Cleveland Engineering Society on March 5, 1956. All-day sessions will embrace seven areas of interest. Subjects to be covered by nationally known authorities include: New materials, design for appearance, design for cost reduction in manufacturing, design problem solving, design and simplified drafting, design for production, and design for humans.

Mini-Mike is a new low-cost, miniature, dynamic, speaker-microphone produced by Telex, Inc., manufacturers of hearing aids.

The compact unit, which weighs only 1⅓ oz, is housed in a steel and plastic case. It can be mount-



FACTS

about

NEW DEPARTURE

BALL BEARINGS

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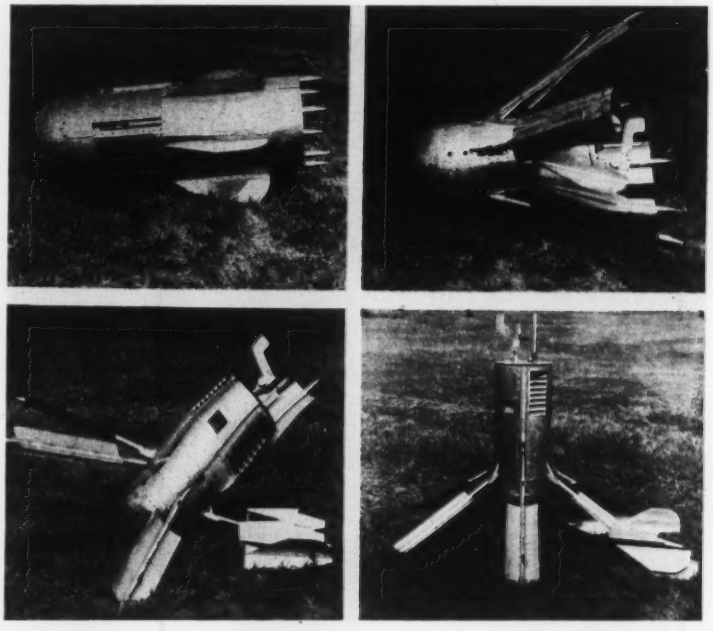
Ask your New Departure sales office about it . . . it's another New Departure "first" in ball bearings!

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

—ITEM 159—

ed in the microphone housing of dictating machines, portable transceivers and other electronic equipment requiring transmitting-receiving units. A miniature transformer designed to match the microphone to the grid circuit can be mounted externally. Dimensions of the unit are 1 x 1 x ¾ in.

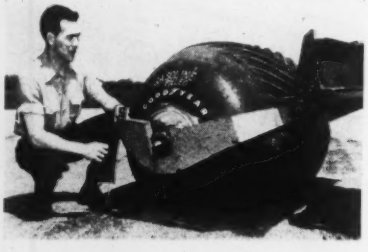
Sensitivity of the microphone with transformer is 52 db below 1 volt per dyne per sq cm of sound pressure. As a speaker, the unit will deliver 120 db with 10 milliwatts of power input. Nominal impedance is 10 ohms.



GRASSHOPPER is the name of this automatic weather station built for the Navy to use in the South Pole expedition Deepfreeze. Dropped by parachute, Grasshopper sets itself up as shown. It measures five items of information and transmits readings every six hours to a radius of 800 miles. It can operate for 60 days without service and at temperatures as low as − 50 F

Vehicle Tire Is Fuel Storage Tank

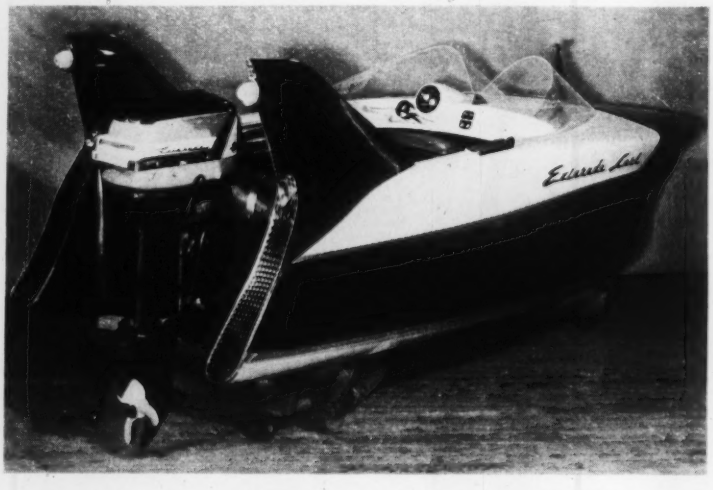
AKRON, O.—A watermelon-shaped rubber tank has been developed by the Aviation Products Div. of Goodyear Tire & Rubber Co. Called the



Rolli-Tanker, the container can be rolled over ground, floated in water, and dropped 15 ft fully loaded, without bursting.

Rolli-Tankers are unconventionally-shaped tires of nylon cord and tread stock construction with fuelproof inner lining. They can be built in a range of sizes. To date, Goodyear has tested 3½ x 5 ft tanks that weigh 40 pounds deflated and have a 250-gallon capacity.

Mounted on hubs and axles to permit easy handling, Rolli-Tankers may be towed manually or by vehicle. Unit ground pressure is very low and drawbar pull is 30 lb.



DON'T CALL IT A DREAMBOAT says Evinrude Motors who engaged designer Brooks Stevens to create this luxury craft. It's right name is Lark. It has bucket-type seats with safety belts for pilot and passenger. Pilot also has speedometer and control switches in easy reach. Stern extensions carry ski tow lines. Evinrude won't sell the boat, just the motor. That's called Lark too

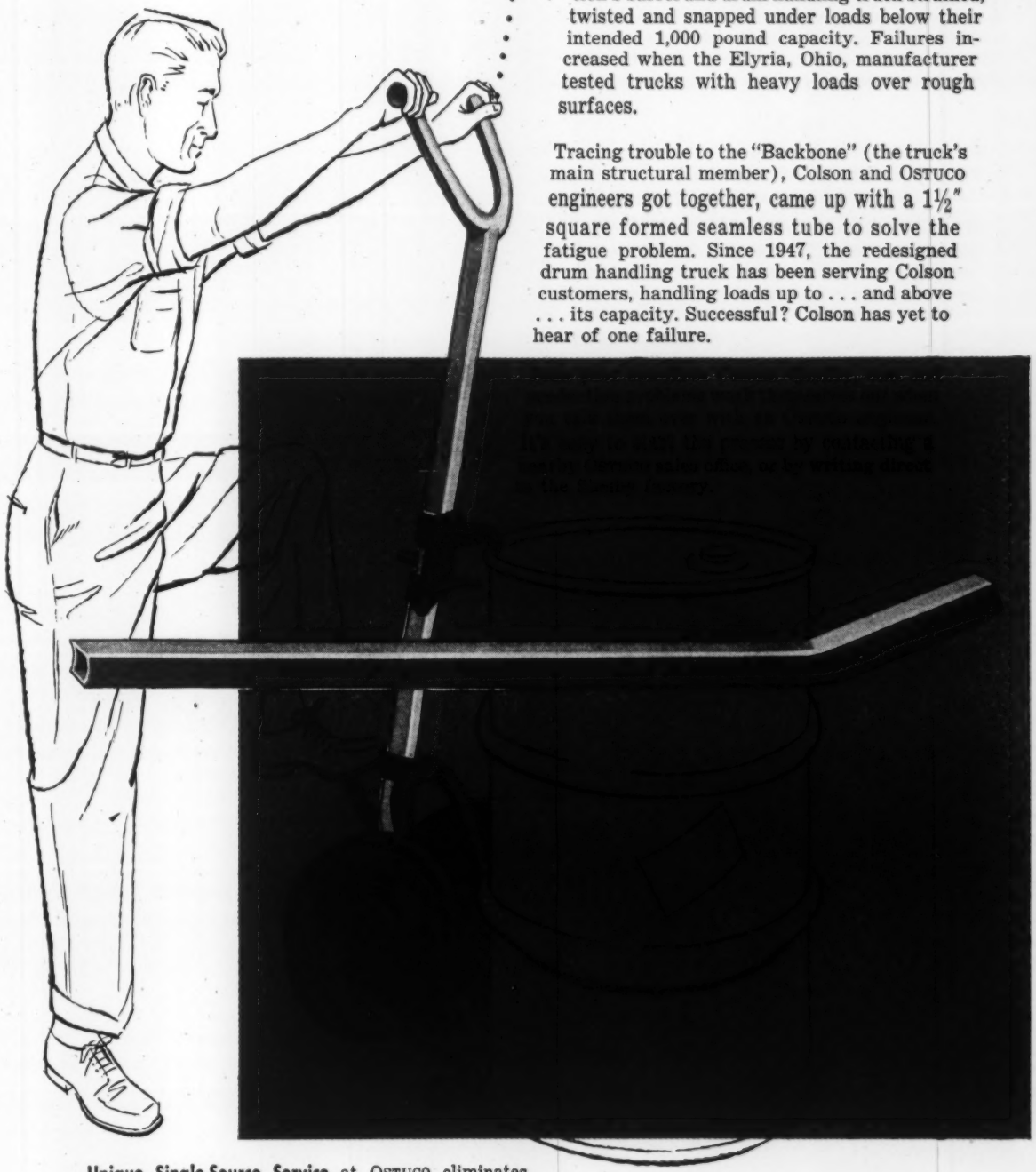
World's most powerful warship, the new U. S. carrier Saratoga has been floated from its construction drydock. The 60,000-ton vessel was towed to a fitting pier. Commissioning is scheduled April 14. Although a sister to the Forrestal, the Saratoga earns the superlative because its steam turbines deliver more than the Forrestal's 230,000 hp.

Dangerous overheating in machines can now be detected by a device which releases a strong, distinctive odor and dense smoke. Humphrey-Wilkinson Inc., chem-

Colson cures

barrel-truck fatigue with

STRONGER BACKBONE FROM OSTUCO



First experimental models of Colson Corporation's barrel and drum handling truck strained, twisted and snapped under loads below their intended 1,000 pound capacity. Failures increased when the Elyria, Ohio, manufacturer tested trucks with heavy loads over rough surfaces.

Tracing trouble to the "Backbone" (the truck's main structural member), Colson and OSTUCO engineers got together, came up with a 1½" square formed seamless tube to solve the fatigue problem. Since 1947, the redesigned drum handling truck has been serving Colson customers, handling loads up to . . . and above . . . its capacity. Successful? Colson has yet to hear of one failure.

Unique Single-Source Service at OSTUCO eliminates interplant shipment and error . . . another reason why your product can be improved when components are made from

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—ITEM 160—

COOPER ALLOY

CORPORATION BRIEFS

• Edited by GEORGE BLACK

AKH #3 NOW AVAILABLE

How to maintain close dimensional accuracy, fine interior and exterior finish and uniform soundness in the casting of a 1¼ lb. stainless steel instrument housing is told in the latest case history in the Cooper Alloy Advanced Know-How series. Ask for AKH #3 and get the full story on the use of shell mold and shell cores in the production of one of those "impossible" castings.

BUNA N FITTINGS

Vanton's line of Buna N and natural hard rubber fittings is described in a newly revised four-page condensed catalog. Diagrams, dimensions, and application data are included. Ask for Bulletin BN.

INQUIRIES AT ALL TIME HIGH

The demand for technical literature of value is on the increase. Our librarian reports more than 20,000 individual pieces of literature requested during the past twelve months, and we're glad to know that we are serving the needs of so many plant operating and purchasing people. For a quick glance at the most recent publications available on request, write for Technical Literature Folder TL56.

OUR FACE IS STILL RED

We're still apologizing to the many people who have requested our deluxe stainless steel valve and fitting catalog. The demand not only exceeded our supply but our ability to process them as well. Even with daily overtime and Saturday work we still haven't caught up with requests . . . so please forgive us if you're one of those on the waiting line.

COOPER ALLOY
CORPORATION • HILLSIDE, N J

—ITEM 161—

FIRST TO USE COMPRESSED AIR is claimed for this tractor made by David Brown Tractors Ltd., England. Powered by a two-cylinder air-cooled diesel engine, the tractor can be fitted with a plow, a cutter bar, or other row crop implements all of which are raised or lowered with compressed air

ical manufacturers of North Haven, Conn., have developed a "Heat Warner" which signals whenever the temperature of equipment rises dangerously. It is now in use protecting railroads against "hot boxes." Requiring no maintenance the Heat Warner can be set to operate at temperatures from 137 to 450 F.

Aero Sciences Institute Elects Honor Members

Others Chosen for Service Awards

NEW YORK—The Institute of the Aeronautical Sciences has announced the election of two honorary fellows and ten fellow members for the year 1955. The late Ralph S. Damon, former president Trans World Airlines, was named the American honorary fellow for 1955. Foreign honorary fellow is Peter G. Masefield, managing director of Bristol Aircraft Ltd., Bristol, England.

Named fellows of the Institute for 1955 are the following: William B. Bergen, executive vice president, Glenn L. Martin Co.; Lars Brising, vice president for aeronautical engineering, Saab Aircraft Company, Sweden; Victor E. Carbonara, president, Kollsman Instrument Corp.; Harold Luskin, assistant chief of aerodynamics, Douglas Aircraft Co.; Dr. Gordon N. Patterson, director of the Institute of Aerophysics, University of Toronto, Canada; Kendall Perkins, vice president for engineering, McDonnell Aircraft Corp.; Raymond H. Rice, vice president and chief engineer, North American Aviation, Inc.; Lewis A. Rodert, assistant to the chief of research, Lewis Flight Propusion Lab., NACA; Rear Adm. James S. Russell, chief of the Bureau of Aeronautics, USN; Professor Hermann Schlichting, Technical University of Braunschweig, Germany.

Fellows of the Institute are chosen on the basis of having "attained a position of distinction in aeronautics and made notable and valuable contributions in one of the aeronautical sciences or aeronautical engineering." Honorary fellows must be "persons of eminence in aeronautics."

To receive its Robert M. Losey Award for 1955, the Institute has chosen Lt. Col. Robert C. Bundgaard, USAF. Col. Bundgaard, who has been in charge of Project Black Sheep for the past three years, is chief of the Evaluation and Devel-

opment Branch, Directorate of Scientific Services, Headquarters, Air Weather Service, USAF. The award has been given annually since 1940 "in recognition of outstanding contributions to the science of meteorology as applied to aeronautics."

Winner of the Lawrence Sperry Award for 1955 is Giles J. Strickroth, manager of the Electronics Department of the Glenn L. Martin Co., Baltimore. He was cited for "contributions to the development of the guidance system for the Martin Matador, the first and only tactical ground-to-ground missile to be put into operational use by the U. S. Air Force."

FASTEST STOP WATCH is this electronic tube developed at Westinghouse for research in nuclear physics. It is said capable of timing atomic events down to less than one billionth of a second

The Sylvanus Albert Reed Award for 1955 has been presented to H. Julian Allen, chief of the high-speed research division of Ames Aeronautical Laboratory, Moffett Field, Calif. Mr. Allen was cited for "contributions and leadership in solving problems in the design of supersonic airplanes and missiles, especially the thermal problems at hypersonic speeds."

The Institute presented the John Jeffries Award for 1955 to Capt. Wilbur E. Kellum, USN, commander of the Naval Medical Research

(*Continued on Page 22*)

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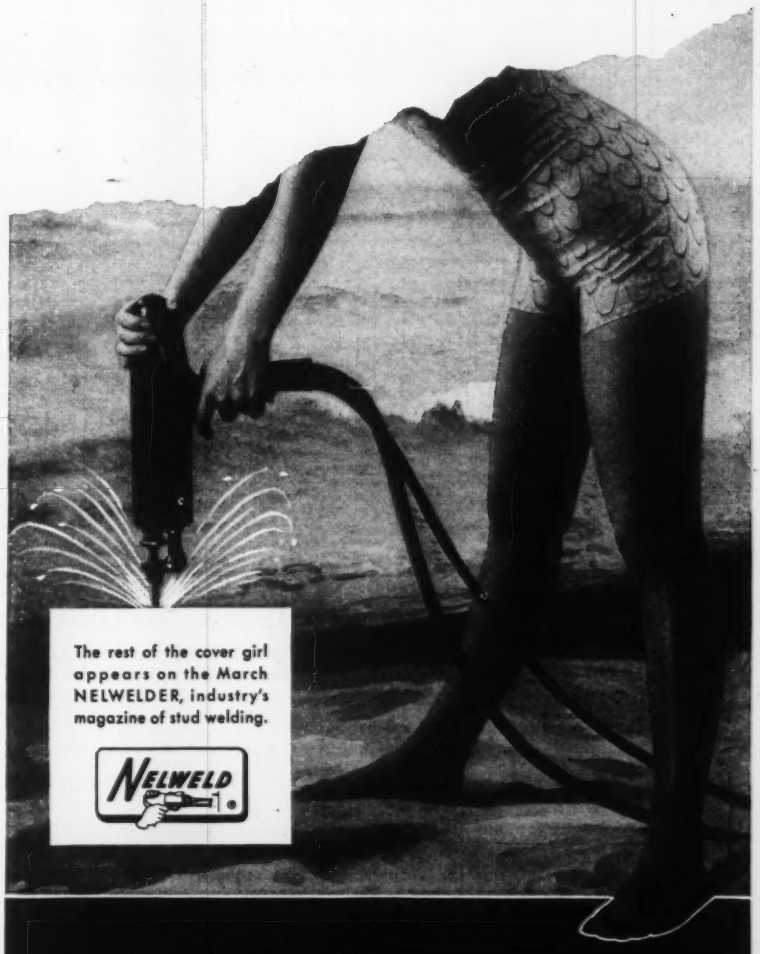

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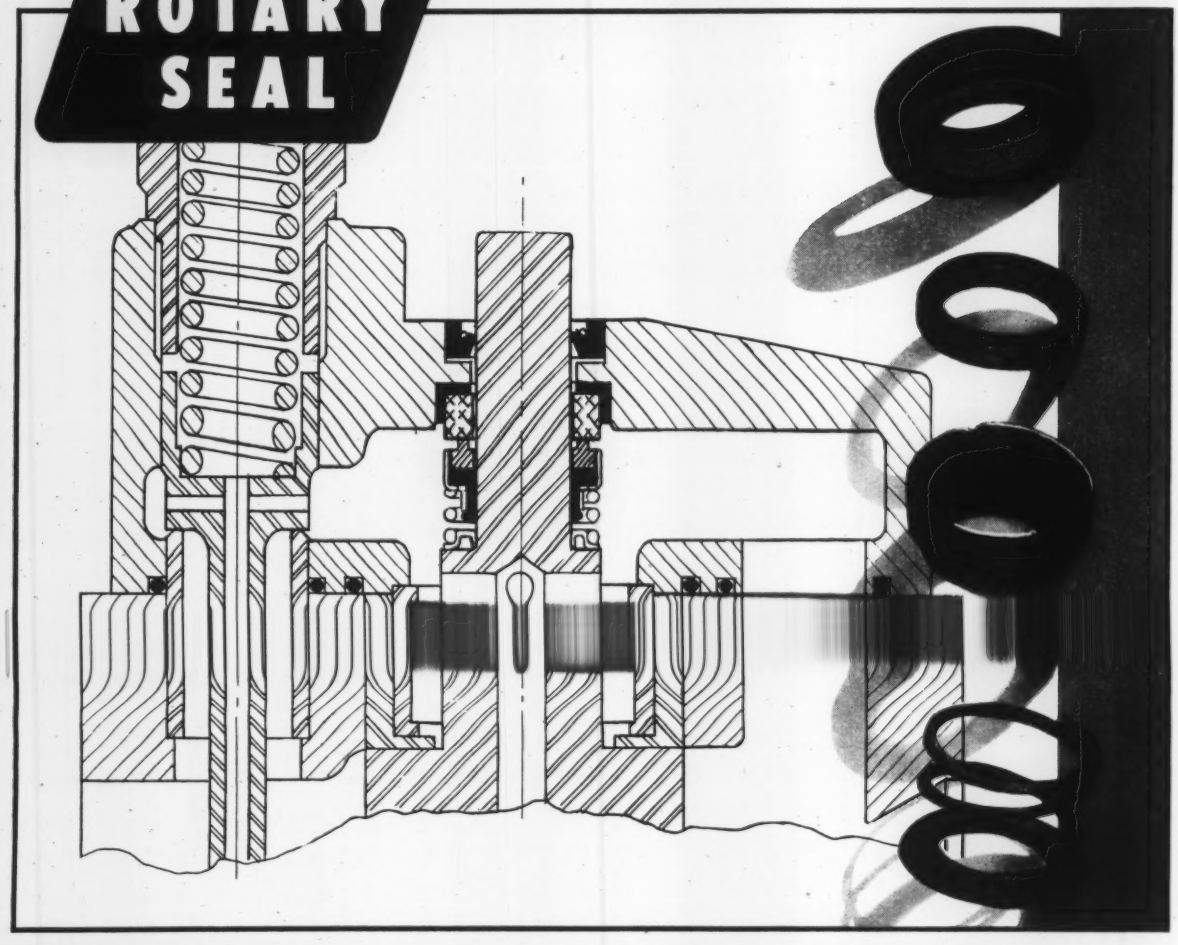
—ITEM 162—

ROTARY SEAL

SPECIALIZED SEAL ENGINEERING



is developing new ways to assure top performance in a TRACTOR HYDRAULIC DIRECTIONAL FLOW VALVE

This rather unusual application of a Shaft Seal neatly solves a problem which could otherwise plague a heavy duty tractor operator a good deal—causing the manufacturer plenty of headaches both in maintenance and sales acceptance.

While the tractor is in use (for example, when ditching) the handle of the flow valve is constantly being turned through a 90° arc to start or stop the hydraulic flow. The requirements for the Seal, therefore, are to combine positive protection against loss of hydraulic fluid, and the very minimum of friction, to permit easy, sure operation. The special ROTARY SEAL illustrated was developed through critical material selection and surface finishing techniques; it is serving efficiently on the job.

You can't reach back on the shelf for a Shaft Seal when your tractor—or your pump, compressor, or whatever your unit may be—must measure up to unusual or especially taxing job requirements. It takes a *custom-designed* Seal—fitted in every detail to the specific job at hand. ROTARY SEAL specializes in developing and manufacturing Seals to meet such problems, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

Major assignments for important Seal developments are keeping us mighty busy at present; but if special difficulties are besetting *your* development programs, and production quantities of Seals are involved, we'll be glad to help if we can.

THE ROTARY SEAL COMPANY

mechanical seals for rotating shafts

Shaft-Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

—ITEM 163—

For More Information Circle Item Number on Yellow Card—page 19

Reader Information Service

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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MACHINE DESIGN
FEB. 23, 1956

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3	33	63	93	123	153	183	213	243	273	303	333	363	393	423	453	483
4	34	64	94	124	154	184	214	244	274	304	334	364	394	424	454	484
5	35	65	95	125	155	185	215	245	275	305	335	365	395	425	455	485
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7	37	67	97	127	157	187	217	247	277	307	337	367	397	427	457	487
8	38	68	98	128	158	188	218	248	278	308	338	368	398	428	458	488
9	39	69	99	129	159	189	219	249	279	309	339	369	399	429	459	489
10	40	70	100	130	160	190	220	250	280	310	340	370	400	430	460	490
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12	42	72	102	132	162	192	222	252	282	312	342	372	402	432	462	492
13	43	73	103	133	163	193	223	253	283	313	343	373	403	433	463	493
14	44	74	104	134	164	194	224	254	284	314	344	374	404	434	464	494
15	45	75	105	135	165	195	225	255	285	315	345	375	405	435	465	495
16	46	76	106	136	166	196	226	256	286	316	346	376	406	436	466	496
17	47	77	107	137	167	197	227	257	287	317	347	377	407	437	467	497
18	48	78	108	138	168	198	228	258	288	318	348	378	408	438	468	498
19	49	79	109	139	169	199	229	259	289	319	349	379	409	439	469	499
20	50	80	110	140	170	200	230	260	290	320	350	380	410	440	470	500
21	51	81	111	141	171	201	231	261	291	321	351	381	411	441	471	501
22	52	82	112	142	172	202	232	262	292	322	352	382	412	442	472	502
23	53	83	113	143	173	203	233	263	293	323	353	383	413	443	473	503
24	54	84	114	144	174	204	234	264	294	324	354	384	414	444	474	504
25	55	85	115	145	175	205	235	265	295	325	355	385	415	445	475	505
26	56	86	116	146	176	206	236	266	296	326	356	386	416	446	476	506
27	57	87	117	147	177	207	237	267	297	327	357	387	417	447	477	507
28	58	88	118	148	178	208	238	268	298	328	358	388	418	448	478	508
29	59	89	119	149	179	209	239	269	299	329	359	389	419	449	479	509
30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510

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Cleveland 13, Ohio

Reader's Service Dept.

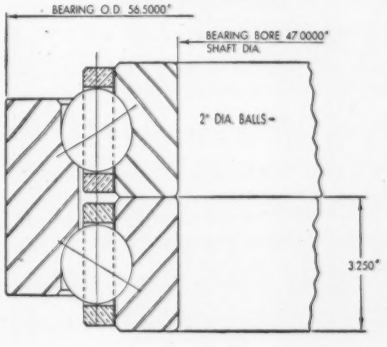
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face runout that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require bearings of exceptional capacity, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



Just Out! Get your copy of the new **KAYDON** *Reali-Slim thin bearing catalog No. 54.*

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K543

PRECISION BALL AND ROLLER BEARINGS

STOP!

PERFECTION

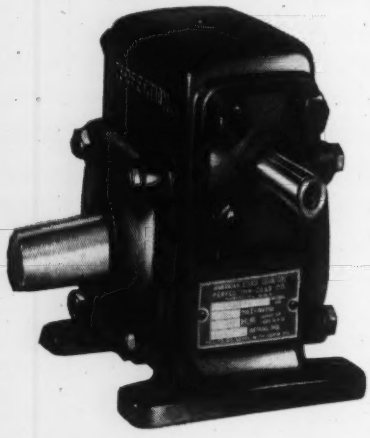
WORM GEAR

SPEED REDUCERS

available in

5

COMPLETE SERIES



Don't go hunting around for Speed Reducers. Your nearest distributor has a complete series of Perfection Speed Reducers with ratios ranging from 5 to 1 to 60 to 1. Furnished with worm on top or bottom as desired.

Shafts are mounted in Timken anti-friction roller bearings. Threads are precision ground and accurately mated with worm gear. Heavy rigid cast iron housings . . . integral worm and shaft. The close limits to which all parts are held, assure maximum load carrying capacity, and long trouble free service.

Write for free 8 page Bulletin No. R-20 listing the complete Perfection Series.

AMERICAN STOCK GEAR DIVISION

Perfection Gear Company • Harvey, Ill. U.S.A.

—ITEM 165—

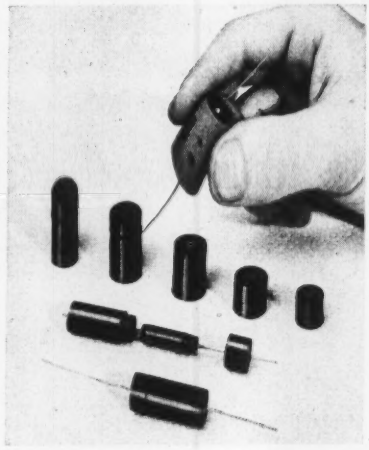
Engineering News Roundup

(*Continued from Page* 15)

Institute at the National Naval Medical Center, Bethesda, Md. The award was given for "outstanding contributions to the advancement of aeronautics through medical research."

During the Honors Night Dinner when the awards were made, the Institute also installed its 1956 president, Dr. Edward R. Sharp, director of the Lewis Flight Propulsion Laboratory, NACA, and named Dr. William R. Sears, director of the Graduate School of Aeronautical Engineering at Cornell University, as editor of its Journal.

Easy assembly is the feature of a new case for electronic components. Developed by Industrial Accessories Inc., the case is made of neoprene, molded in two pieces and lined with phenolic resin. In the end of each piece is a compression eyelet crimped to the shell with holes through which the component's leads are passed. After manual assembly, voids in the case are filled by drawing wax or oil through the eyelets, and sealing is completed by soldering the lead wires to the eyelets.



New mercury cells are so designed that a number can be stacked to provide required voltage in a variety of shapes. Design permits automation in the assembly of the cells in stacks.

Made by P. R. Mallory & Co., the batteries are available in standard miniature sizes for 15, 22.5, and 45 volts. Diameter of the unit cell is 0.490 in. and overall height is 0.280 in. When cells are nested, the net height of each is 0.210 in.

Meetings

AND EXPOSITIONS

March 12-15—

National Electrical Manufacturers Association. Midwinter Meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 155 East 44th St., New York 17, N. Y.

March 14-15—

American Society of Mechanical Engineers. Engineering Management Conference to be held at Hotel Statler, St. Louis, Mo. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 14-16—

American Society of Mechanical Engineers. Aviation Division Conference to be held at Hotel Statler, Los Angeles, Calif. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 18-21—

American Society of Mechanical Engineers. Spring Meeting to be held at the Multnomah Hotel, Portland Ore. Additional information may be obtained from society head-

NOTHING *can equal Stainless Steel*

FOR EASY CLEANING. In this textile plant of W. J. Dickey & Sons, Inc., dyeing time *and* costs have been cut 50% with the use of Stainless Steel equipment. When colors are changed, tanks don't have to be boiled out. With its smooth, dense surface, Stainless can be cleaned easily and quickly.

FOR CORROSION RESISTANCE. The Norwich, N. Y. plant of Norwich Pharmacal Company is a magnificent display of Stainless Steel. Shown here is a Stainless Steel filter, used to separate mother liquor from the solids of furoxone. Here, Stainless outlasts any other practical metal by two to one.

FOR CONSUMER APPEAL. Now, just about every housewife knows what Stainless Steel is. When she sees the Stainless tub in this automatic laundry, made by Speed Queen Corp., Ripon, Wis., she knows that there is nothing to corrode. She knows, too, that the Stainless tub will stay bright and clean and will last forever.

No other design material can match Stainless Steel in its *combination* of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When buying Stainless, remember that United States Steel offers the widest range of types, finishes and sizes available in the United States.

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

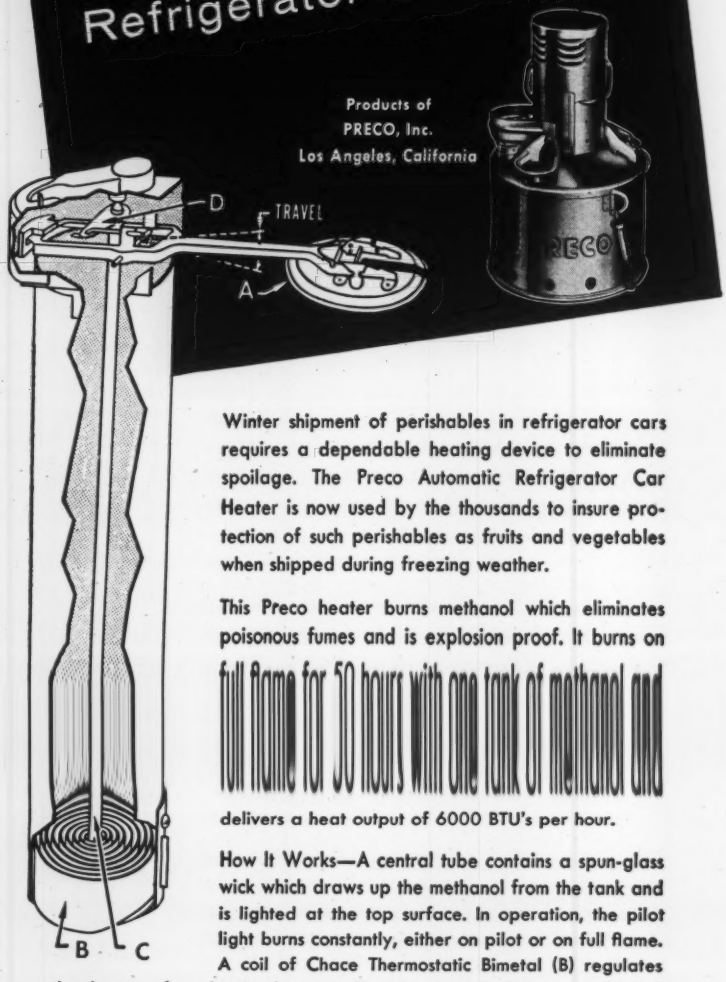
UNITED STATES STEEL

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALABAMA • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

XUM

How Chace Thermostatic Bimetal Controls the PRECO Refrigerator Car Heater

Products of
PRECO, Inc.
Los Angeles, California



Winter shipment of perishables in refrigerator cars requires a dependable heating device to eliminate spoilage. The Preco Automatic Refrigerator Car Heater is now used by the thousands to insure protection of such perishables as fruits and vegetables when shipped during freezing weather.

This Preco heater burns methanol which eliminates poisonous fumes and is explosion proof. It burns on full flame for 50 hours with one tank of methanol and delivers a heat output of 6000 BTU's per hour.

How It Works—A central tube contains a spun-glass wick which draws up the methanol from the tank and is lighted at the top surface. In operation, the pilot light burns constantly, either on pilot or on full flame. A coil of Chace Thermostatic Bimetal (B) regulates the degree of combustion by controlling the amount of oxygen admitted to the wick, according to the temperature in the car. The bimetal coil, with one end fixed to the housing and the other to the shaft (C), reacts to temperature change by rotating the shaft with lever (D) attached, lifting or lowering the snuffer arm and plate (A) over the flame. Thus, the amount of oxygen available for combustion is varied to produce a greater or lesser degree of heat.

Chace Thermostatic Bimetal is available in 29 types, in strip, coils or in complete elements made to your specifications. Write now for our free 36-page booklet, "Successful Applications of Thermostatic Bimetal," containing valuable information for designers of thermally responsive devices.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

—ITEM 167—
For More Information Circle Item Number on Yellow Card—page 19

News Roundup

quarters, 29 West 39th St., New York, N. Y.

March 19-20—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago, Ill. George K. Dreher, 606 Terminal Tower, Cleveland 13, O., is secretary.

March 19-21—

Society of Automotive Engineers. National Production Meeting and Forum to be held at Hotel Statler, Cleveland, O. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

March 19-22—

Institute of Radio Engineers. National Convention to be held at the Waldorf-Astoria Hotel and Kingsbridge Armory, New York, N. Y. Additional information may be obtained from society headquarters, 1 East 79th St., New York, N. Y.

March 19-23—

American Society of Tool Engineers. Industrial Exposition and Annual Convention to be held at the International Amphitheatre, Chicago, Ill. Harry E. Conrad, 10700 Puritan Ave., Detroit 38, Mich., is executive secretary.

March 21-23—

American Power Conference to be held at Hotel Sherman, Chicago, Ill. Sponsored by Illinois Institute of Technology in co-operation with 13 universities and nine national and regional societies. Roland A. Budenholzer, Technology Ctr., Chicago 16, Ill., is conference director.

March 26-27—

American Society of Mechanical Engineers. Instruments and Regulators Division Conference to be held at Princeton University, Princeton, N. J. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 26-28—

American Management Association. Manufacturing Conference to be held at the Statler Hotel, De-

troit, Mich. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 36, N. Y.

April 1-5—

American Society of Mechanical Engineers. Oil and Gas Power Division Conference to be held at the Jung Hotel, New Orleans, La. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

April 2-4—

American Institute of Electrical Engineers. South West District Meeting to be held at Dallas, Texas. Additional information may be obtained from society headquarters, 33 West 39th St., New York, N. Y.

April 4-6—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the William Penn Hotel, Pittsburgh, Pa. William P. Youngclaus, Jr., 84 E. Randolph St., Chicago 1, Ill., is administrative secretary.

April 10-11—

American Society of Mechanical Engineers. Machine Design Division Conference to be held at the Bancroft Hotel, Worcester, Mass. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

May 2-4—

Industrial Fasteners Institute. Annual Meeting to be held at the Homestead, Hot Springs, Va. R. B. Belford, 1517 Terminal Tower, Cleveland 13, O., is secretary.

May 14-17—

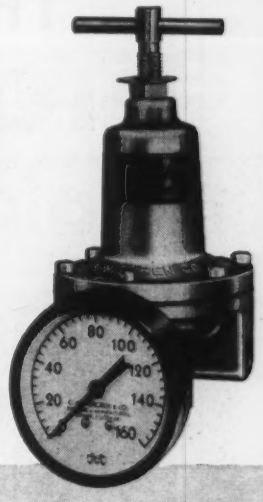
Design Engineering Show and Conference to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland

NORGREN
AIR PRESSURE REGULATORS

Accurate, Dependable Control of Air Pressure



There's a Norgren Regulator for Every Air Regulation Need.

All air-operated equipment is designed to operate most efficiently at one specified air pressure. Pressures in excess of this specified pressure result in greater wear, more downtime, higher maintenance cost and waste of air. You can select a Norgren Regulator that will provide the desired pressure at all times, holding it constant even though the line pressure or rate of flow may vary.

How Norgren Regulators Provide Accurate, Trouble-Free Service...

1. PRECISION CONSTRUCTION

Norgren Pressure Regulators are precision built throughout to provide accurate pressure regulation under the most rugged conditions.

2. PRESSURE KEPT CONSTANT

Norgren Pressure Regulators respond quickly to sudden demands for greater air volume without an excessive momentary pressure drop.

3. EFFICIENT OPERATION

A baffle plate and siphon tube permits greater air flow with less pressure drop and protects the diaphragm against sudden pressure surges and chatter.

4. LONG-WEARING DIAPHRAGM

The diaphragm in Norgren Pressure Regulators is made of oil-resistant synthetic rubber reinforced with nylon fabric.

5. RELIEVING FEATURE

The built-in relieving feature available on all models safeguards connected equipment against damage through pressure surges—permits downward adjustment of pressure without auxiliary "bleeding" of line.

6. EASY TO INSTALL

Pipe connections are straight through for easy installation. In addition, most models can be completely dismantled without removing them from the air line.

Without obligation, learn how Norgren Pressure Regulators can reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory, or **WRITE THE FACTORY FOR NEW NO. 700 CATALOG.**

C.A. Norgren CO.

3442 So. Elati St., Englewood, Colo.

Wherever Air is Used in Industry

NEARLY 400 STANDARD MODELS

NORGREN AIR PRESSURE REGULATORS, RELIEVING

Relieving feature provides added protection against excessive pressure build-up. Permits downward adjustment of pressure without "bleeding" of line. Maximum allowable primary pressure is 450 psi; adjustable delivery pressure is 2 to 250 psi. Pipe sizes—⅛" to 1" inclusive. Series 2AX.

NORGREN AIR PRESSURE REGULATORS, STANDARD

Maximum allowable primary pressure is 450 psi; adjustable delivery pressure is 2 to 250 psi. Pipe sizes—⅛" to 1" inclusive. Series 2A.

NORGREN AIR PRESSURE REGULATORS, PRECISION

For precise control of air pressure in the range of 0 to 2 cfm. Specially suited for use with air-controlled instruments. Maximum allowable primary pressure is 400 psi; adjustable delivery pressure is 1 to 30 psi. Relieving type. Pipe size—¼". Series 11,400.

NORGREN AIR PRESSURE REGULATORS, PILOT-CONTROLLED

A precisely controlled air cushion provides an extended adjustable range, more accurate pressure regulation, increased capacity in cfm. Maximum allowable primary pressure is 400 psi; adjustable delivery pressure is 2 to 120 psi. Pipe sizes—½", ¾", 1". Series 20AA.

—ITEM 168—

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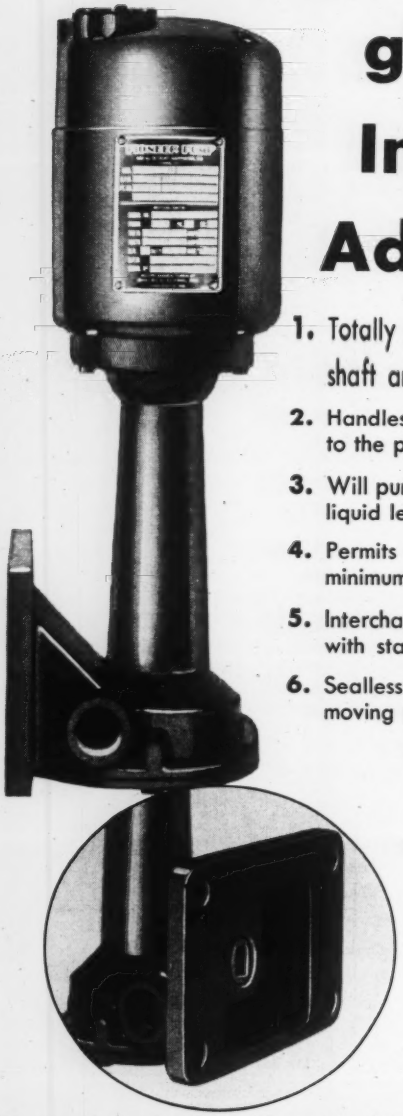
This New PIONEER Coolant Pump gives you Important Advantages



1. Totally enclosed motor, with extra-heavy shaft and heavy-duty ball bearings.
2. Handles abrasives or chips without injury to the pump.
3. Will pump down to 1 1/16"; self-priming to 1" liquid level.
4. Permits clean-out of machine sump with minimum time and labor.
5. Interchangeable with any make pump with standard mounting dimensions.
6. Sealless design with no metal-to-metal moving parts.
7. Can be furnished with any desired electrical characteristics.
8. Three optional outlets: left external, right external, center outlet through mounting flange. The latter permits compact, clean-cut design of machine with no exposed piping.

Pioneer offers more than 400 models of impeller-type and positive displacement pumps to meet every coolant pump requirement; or we will develop designs for specific applications. Our application engineers will welcome the opportunity to discuss your pump requirements with you.

Send for our illustrated booklet covering the basic Pioneer designs in both impeller-type and positive displacement pumps.

PIONEER PUMP DIVISION
DETROIT HARVESTER COMPANY
Sales Office: 5450 West Jefferson Ave., Detroit 9, Michigan
Plant: Paris, Kentucky

—ITEM 169—
For More Information Circle Item Number on Yellow Card—page 19

MEN
OF MACHINES

In reorganizing its Engineering Div., Chrysler Corp., Detroit, has named **Paul C. Ackerman** to the newly created position of director of engineering. Mr. Ackerman will serve as chairman of the division's new Engineering Executive committee, which is composed of engineers in charge of product planning, styling, research, administration, testing, management planning, and body, chassis, electrical and truck engineering. Mr. Ackerman was associated with Timken Detroit Axle Co. and was assistant chief engineer of the Timken Roller Bearing Co. before joining Chrysler in 1934. He had charge of engineering road testing for four years; was appointed assistant chief engineer, then chief engineer of laboratories; and in 1953 was named executive engineer.

Paul C. Ackerman

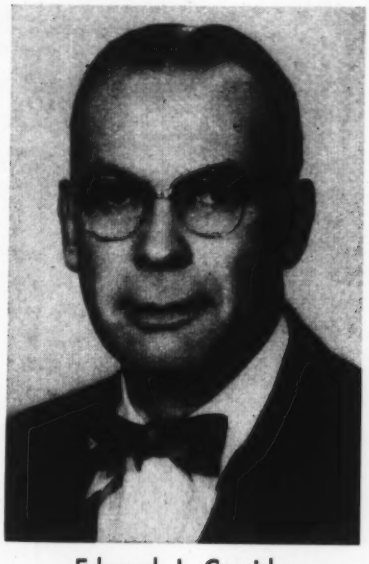
Appointment of **John M. Miller Jr.** as works manager and **Stanley R. Scheiner** as director of engineering of the television and broadcast receiver division has been announced by Bendix Aviation Corp., Baltimore. Mr. Miller has been director of engineering for Bendix

Television for almost a year and prior to that was chief engineer. Mr. Scheiner, assistant director of engineering since April, 1955, has been one of the principal engineers for Bendix Television for the last six years.

R. C. Poucher has been appointed chief engineer by Nutt-Shel Co. Inc., Glendale, Calif.

Having recently joined the division as assistant chief engineer, **Herbert H. Schmiel** has been named chief engineer of the Industrial Hydraulics Div. of Parker Appliance Co., Cleveland. Mr. Schmiel had been associated with the Hydreco Div. of New York Air Brake Co. for 15 years, the last 6 years as assistant chief engineer.

Edward J. Cassidy has been appointed director of quality control for the home appliance division of Servel Inc., Evansville, Ind. Mr. Cassidy has been on special assignments since joining Servel last September. He was previously director of engineering for Glascock Brothers Mfg. Co. and also has



Edward J. Cassidy

been affiliated with Ontario Mfg. Co., American Transformer Co., Gray Mfg. Co., and Sperry Gyroscope Co. Inc.

Isaac F. Kinnard has been named manager of special projects and studies at the instrument department of General Electric Co. in

(*Continued on Page* 30)

DESIGNERS

if you have a dead-end job

send us your telephone number

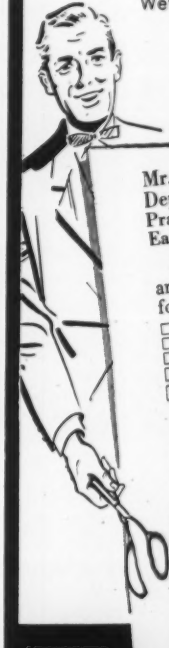
If you are stuck in a job without a future, it will pay you to investigate the wide variety of openings in our engineering department.

Here, the designer is a key man. He has a virtually unlimited opportunity to gain recognition and advancement. Outstanding men can, and frequently do, build sound, well-rewarded careers in a hurry.

In addition, there are other important advantages: new, higher salary ranges, liberal employee benefit programs, pleasant New England living, many others.

Fill in and mail the attached coupon immediately. We'll treat it confidentially; reply without delay. Your action now may be the first step toward a far better future for you and your family.

Be sure and include your telephone number. We may want to call you.



Mr. E. M. Peterson
Dept. 4, Design Employment
Pratt & Whitney Aircraft
East Hartford 8, Conn.

I would like to learn more about your openings for product and component designers. My experience has been in the following fields:

☐ Nuclear Design
☐ Compressors
☐ Turbines
☐ Structures
☐ Afterburners and Related Equipment
☐ Aerodynamics
☐ Hydraulics
☐ Gears
☐ Valves
☐ Heat Exchangers and Combustion Problems
☐ Bearings
☐ Piping
☐ Controls
☐ Test Equipment
☐ Test Rigs
.....

Total years Mechanical Design experience .....

You can reach me at..... (telephone) Most convenient hours for receiving calls are between.....and.....

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Division of United Aircraft Corporation
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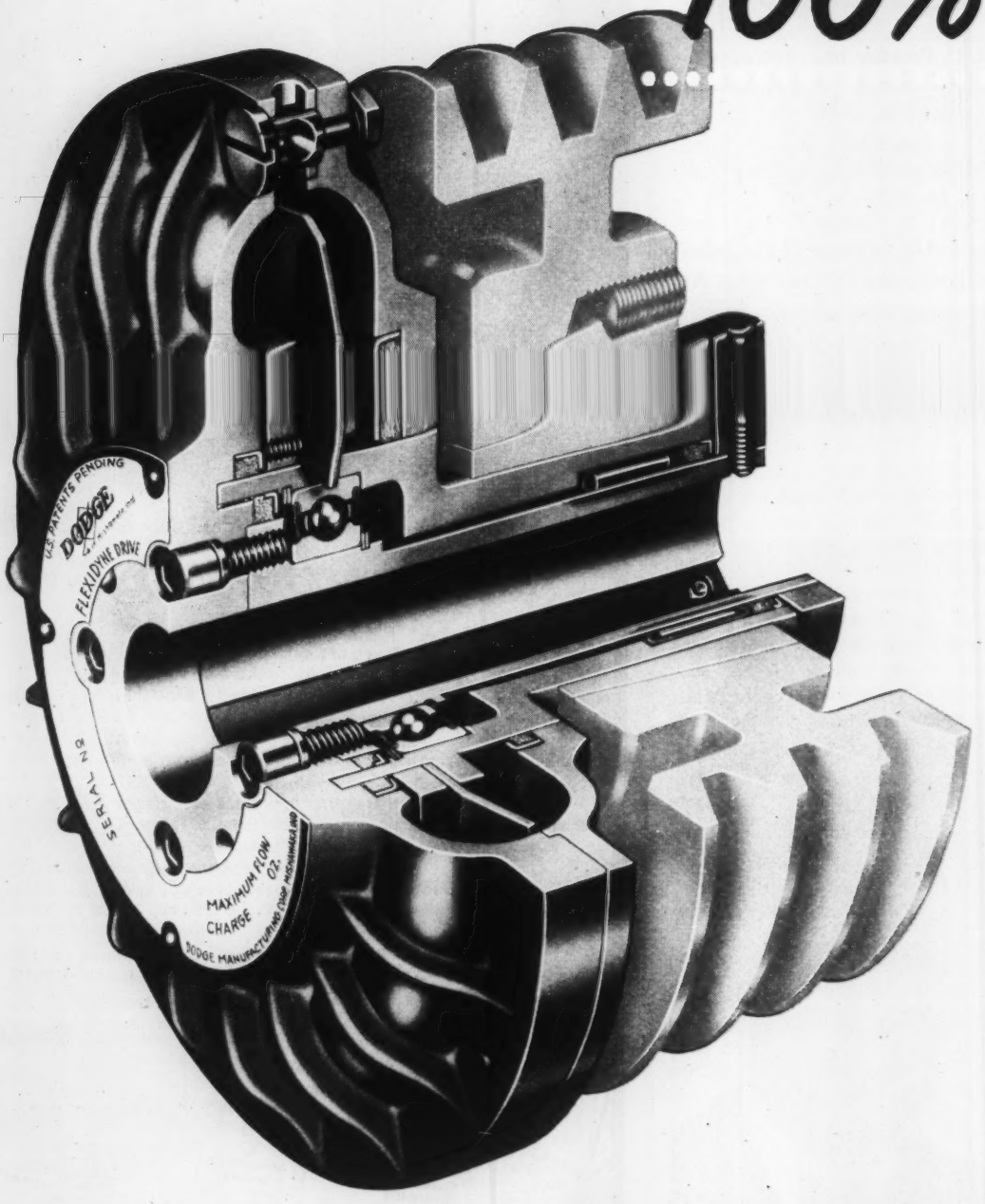
World's foremost designer and builder of aircraft engines

—ITEM 170—

100%



THE NEW DEVELOPMENT THAT

- —STARTS LOADS SMOOTHLY
- —PROTECTS AGAINST SHOCKS AND OVERLOADS
- —SAVES POWER
- —GIVES 100% EFFICIENCY AT FULL LOAD

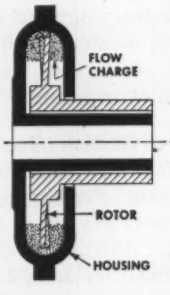
Efficiency at Full Load!

FLEXIDYNE

THE DRY FLUID DRIVE

Field experience proves that the new principle employed in Flexidyne provides a better way to handle difficult drive problems.

The "dry fluid" in Flexidyne is heat treated steel shot. A measured amount, called the flow charge, is contained in the housing, which is keyed to the motor shaft. When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, wedging it between the housing and the rotor which transmits power to the load.



After a momentary slip between housing and rotor the two become locked together and achieve full load speed without slip and at 100% efficiency during the running cycle.

Flexidyne is easy to select *off the shelf.* Each size has a standard horsepower rating, yet the flow charge can be varied quickly to give you tailor-made torque to suit the job.

Write for bulletin A-640, or call your Dodge Distributor now about Flexidyne Drives and Flexidyne Couplings.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

FLEXIDYNE AT WORK TURNS IN GREAT PERFORMANCE RECORD!

Flexidyne Drives and Couplings are now being delivered from stock. Already reports like these are coming in about Flexidyne performance in many tough assignments.

RAILROAD CAR PULLERS
"Starts fine... summer or winter!"

CONVEYORS
"We start under full load now!"

COTTON CARDS
"Finally... the soft start!"

TRAVELING CRANES
"Spots our loads... and how!"

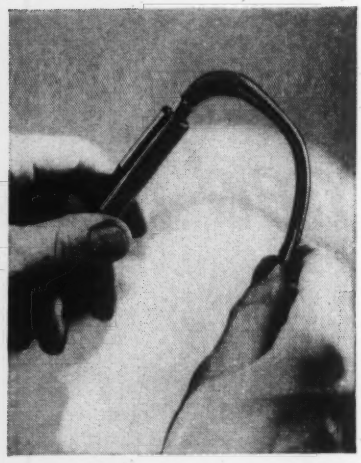
PUMPS
"Now we are using smaller motors, too!"

VENTILATING FANS
"Takes off smooth as silk!"

...AND OTHER HEAVY INERTIA LOADS
"Wonderful performance!"

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone book, or write us.

DODGE
of Mishawaka, Ind.



New spring stress reliever increases operating life

CHROMALOX
Electric
CARTRIDGE HEATERS

On applications which require repetitive flexing action, you can now obtain Chromalox Electric Cartridge Heaters equipped with an ingenious high tensile spring—which protects the lead wire against premature breakage.

The spring—which is mechanically locked to the cartridge heater and is not affected by heat—follows the lead wire a sufficient distance to prevent sharp twists from breaking the wire. Laboratory testing indicates that operating life of the lead wire can be increased up to 10 times with this spring stress reliever.

Chromalox Electric Cartridge Heaters equipped with the spring stress reliever are available in ⅜", ½", ⅝" and ¾" diameters.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically.

Write for your copy of Bulletin 850

for more specific information on Chromalox Electric Cartridge Heaters.

For information on the complete line of Chromalox Electric Heaters request Catalog 50.

Edwin L. Wiegand Company
7575 Thomas Boulevard • Pittsburgh 8, Pennsylvania

EDWIN L. WIEGAND COMPANY
7575 Thomas Boulevard, Pittsburgh 8, Pa.
I would like to have—
☐ a copy of Bulletin 850
☐ a copy of Catalog 50
☐ a Sales-Engineer contact me.

Name_____
Company_____
Street_____
City_____ Zone____ State_____
A-4457A

—ITEM 172—

Men of Machines

(*Continued from Page 27*)

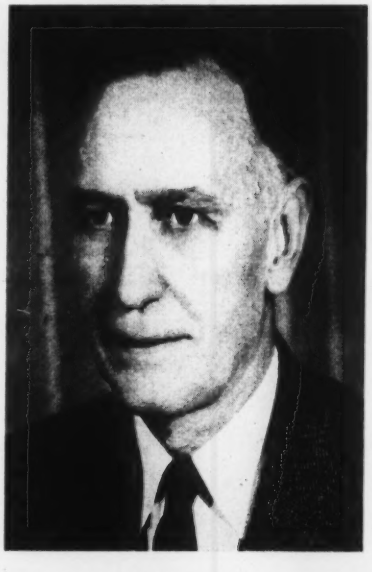
Lynn, Mass. **Mark A. Princi** has been appointed manager of engineering to succeed Mr. Kinnard, and **Thomas O. Paine** replaces Mr. Princi as manager of the measurements laboratory.

Executive vice president since 1948, **W. G. Frank** has been named president of the American Air Filter Co., Louisville. Mr. Frank has been associated with the company since 1929, when it was organized through a consolidation of five air filter companies, one of which he had served as chief engineer.

S. P. Kinney Engineers Inc., Carnegie, Pa., has announced the election of **Ward W. Clarke** as vice president in charge of engineering. He is succeeded as chief engineer by **Hugh B. Carr,** who was formerly associated with Steel Co. of Canada Ltd.

Square D Co., Detroit, has named **John D. Leitch** vice president of engineering and **Asa H. Myles** chief engineer and a member of the operating committee of its newly acquired Electric Controller and Mfg. Co. Div. in Cleveland. Dr. Leitch, with headquarters in Detroit, will co-ordinate engineering activity for Square D plants in nine cities in the United States, as well as in Toronto and Mexico City. He joined Electric Controller in 1937 in charge of

John D. Leitch



Asa H. Myles

product development, was named chief engineer in 1943 and a vice president in 1952. Previously he was associated with the Steel Co. of Canada and was a member of the faculty of the University of Toronto.

Mr. Myles joined Electric Controller as a test engineer in 1930, subsequently became a control engineer and, since 1943, has been assistant chief engineer.

Sterling Precision Instrument Corp., Buffalo, has announced formation of the Cambridge Engineering Laboratory as a new facility of its Instrument Div. and the appointment of **John J. Jarosh** as director. Mr. Jarosh's background in instrumentation includes experience as chief designer for the Navy's Mark XIV gyroscopic gun sight.

Formerly director of engineering, **Marvin L. Stark** has been elected vice president of engineering and development for Peerless Mfg. Corp., Louisville.

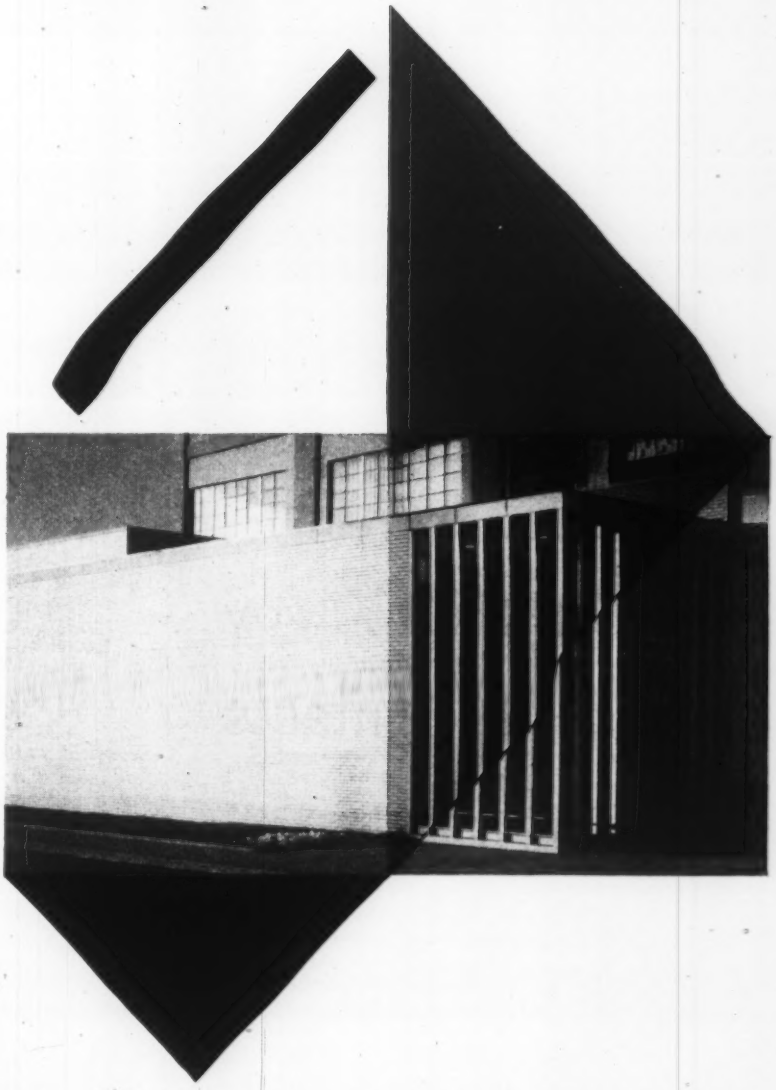
George A. Delaney, chief engineer of General Motors' Pontiac Motor Div., has been inaugurated as president of the Society of Automotive Engineers for 1956. Mr. Delaney has been active in the SAE and has served as member and chairman of the Technical Board. He has been associated with Pontiac since 1934.

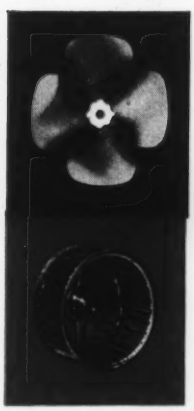
If you are in the business of manufacturing air-moving products or appliances, this is an invitation to you to visit the world's finest plants and engineering facilities devoted exclusively to the development of air-impeller equipment.

Manufacturing divisions are located at Torrington, Connecticut (headquarters), Van Nuys, California, and Oakville, Ontario. And Torrington's products and services are available to you through an organization of sales representatives with offices located in 25 metropolitan and industrial areas.

Call us—or come, and bring your problems with you!

THIS IS TORRINGTON





THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

—ITEM 173—

SNAP-LOCK LIMIT SWITCHES. Made in both single-pole and double-pole series, and in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

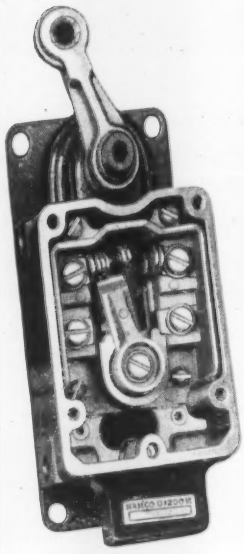
NATIONAL ACME

SNAP-LOCK

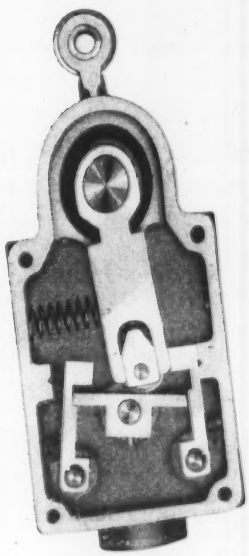
TRADE MARK

THE ORIGINAL

SNAP-ACTION LOCKING SWITCH



ELECTRICAL SIDE



MECHANICAL SIDE

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is oil and dust resistant. Can also be furnished water and oil-tight.

PROVED . . . by millions of contacts

SNAP-LOCK Push Button Control Station Switches

Made up of small SNAP-LOCK switches, with separate enclosures for electrical and mechanical sides. Adaptable to any number of units and in any arrangements of buttons, in flush or surface mounted types. For AC or DC service.

SNAP-LOCK Motor Starter Switches

SNAP-LOCK Motor Starter switches are designed for 3-phase motors to 7½ HP on AC ½ HP on DC.

All National Acme Switches—Limit Switches, Push-Button Control Station Switches and Motor Starter Switches—employ the same dependable, basic **SNAP-LOCK** design. As illustrated above, the snap-action locking mechanism is simplicity itself—fool-proof, accessible, and long-lived. The double-throw contact lever is connected directly by shaft with the latch bar on the mechanical side and carries self-wiping coin silver contact points to insure quick action make and break, with maximum wear resistance.

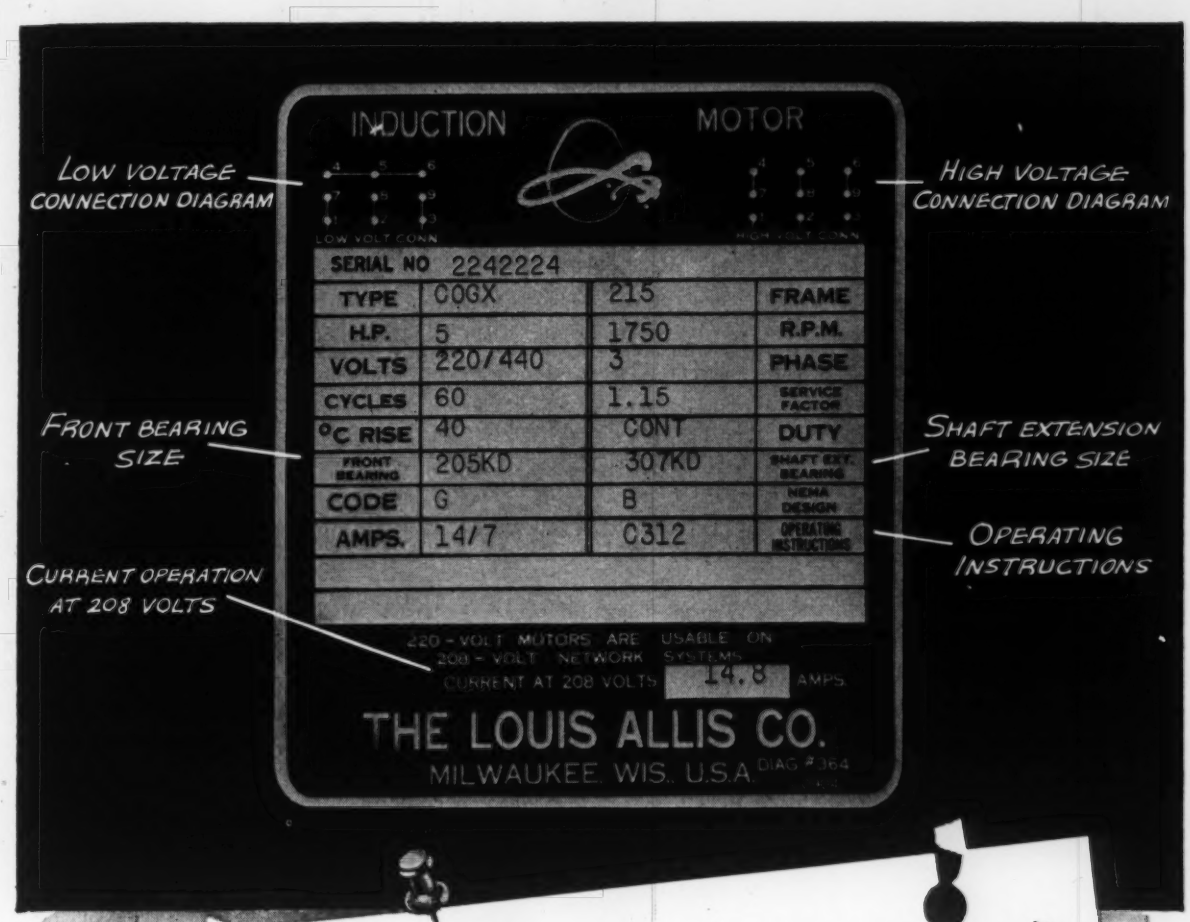
Send for Bulletin EM-51, or let us discuss your design problems with you.

ELECTRICAL MANUFACTURING DIVISION

National Acme

The National Acme Company • 188 East 131st Street, Cleveland 8, Ohio

—ITEM 174—
For More Information Circle Item Number on Yellow Card—page 19


LOW VOLTAGE CONNECTION DIAGRAM
HIGH VOLTAGE CONNECTION DIAGRAM
FRONT BEARING SIZE
SHAFT EXTENSION BEARING SIZE
OPERATING INSTRUCTIONS
CURRENT OPERATION AT 208 VOLTS
INDUCTION MOTOR
LOW VOLT CONN
HIGH VOLT CONN
SERIAL NO 2242224
TYPE C0GX 215 FRAME
H.P. 5 1750 R.P.M.
VOLTS 220/440 3 PHASE
CYCLES 60 1.15 SERVICE FACTOR
°C RISE 40 CONT DUTY
FRONT BEARING 205KD SHAFT EXT. BEARING 307KD
CODE G B NEMA DESIGN
AMPS. 14/7 C312 OPERATING INSTRUCTIONS
220 - VOLT MOTORS ARE USABLE ON 208 - VOLT NETWORK SYSTEMS
CURRENT AT 208 VOLTS 14.8 AMPS.
THE LOUIS ALLIS CO.
MILWAUKEE WIS. U.S.A. DIAG # 364

why is this nameplate important to you?

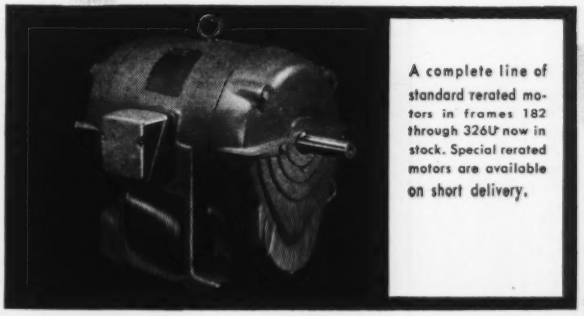
It provides visible evidence that Louis Allis standard motors are built with special care to run better, last longer . . .

Look at the information on this nameplate—information that makes life a lot easier for the user. And to keep this information available at all times, we make this nameplate out of corrosion-resistant stainless steel.

Yes, in the new LA line of standard motors, even the nameplate gets special attention from our engineers. And here's what it means to you:

- The rerated frame size shown means more horsepower from motors with smaller outside dimensions. Performance has been improved by new materials and manufacturing methods.
- Spare bearings can be easily ordered from bearing size and type designations on nameplate, thus eliminating disassembly of motor to determine bearing size. Bearings used are conservatively rated for long life.
- No more lost connection diagram since this information is simply and clearly shown on nameplate. This combined with permanent lead markings, assures that correct motor connections can always be made.
- 220/440 volt motors are suitable for operation on 208 volt systems and full load current for 208 volt operation is included on the nameplate. This eliminates need for original equipment manufacturers to carry a stock of 208 volt motors.

Because they are built with special care, new LA standard motors can do a lot more for you. New bulletin No. 1700 shows you why—just write for your copy.



A complete line of standard rerated motors in frames 182 through 326U now in stock. Special rerated motors are available on short delivery.

LA-106

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

—ITEM 175—

(Advertisement)

Carboloy Trends and Developments for Design Engineers...

• How complex permanent-magnet assemblies are built to desired field patterns from simple magnet shapes

G-E Alnico magnets provide unlimited design flexibility

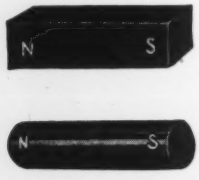
The fundamental problem in designing with permanent magnets is how to provide a specific magnetic flux in a desired field pattern.

In solving this problem, a designer can choose from seven General Electric Alnico grades, hundreds of styles, weights from a fraction of an ounce to a hundred pounds. He can use magnets with two poles – or many poles; with poles at the ends – or anywhere along the magnetic axis.

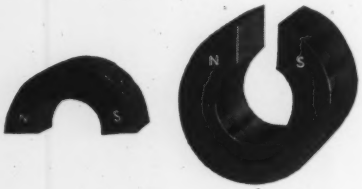
This all gives tremendous flexibility to the design of permanent magnets and magnet assemblies. But precisely because there are so many sizes, shapes, strengths, and other factors to be considered, this flexibility can make the designer's job far more complicated.

So, to help give a clearer understanding of what can and cannot be done with G-E Alnico permanent magnets, we have prepared this description of basic magnet shapes.

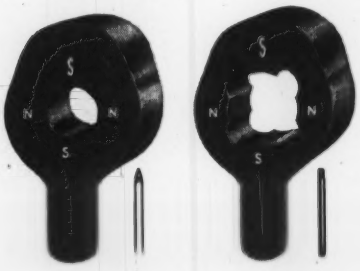
The simplest forms of a permanent magnet are the bar and rod. They are normally salient (i.e., the poles occur at the ends), and may be of any cross-sectional area.



U- and C-shaped magnets are simply bars "bent" to bring both poles to the same plane.



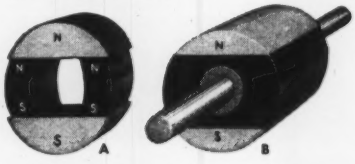
Carry the bending process to its ultimate conclusion and you have the cylinder (see top of next column) with or without the hole. A cylindrical magnet can be magnetized with as many poles as desired on the outside diameter (A), or the inside diameter (B). Not only can the size and shape of the hole be varied, but the magnet can be made salient (B), or nonsalient (A).



All other forms are merely variations on the original themes, even to such nonstandard shapes as these:

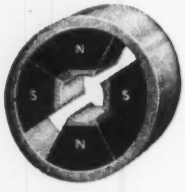
Use of pole pieces adds to design possibilities

One basic use of pole pieces is to provide a return path for the magnetic flux. Pole pieces may be solid (B), or laminated, like this generator magnet (A).



Designers can easily assemble pole pieces and properly shaped permanent magnets to obtain their required field patterns.

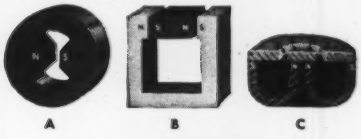
One version is this stator assembly, designed to provide inner poles. The



design can be altered in various ways, depending on mechanical, space, magnetic, or physical properties required.

For example, here is another 4-pole magnet using soft steel. It is also possible to construct an assembly with as many poles as required–by using a number of bar magnets or by using one 2-pole magnet.

Perhaps the most important consideration in the design of magnetic assemblies is the amount of flux across the air gap. These air gaps may be single (A), double (B), or annular (C).



Soft-steel pole pieces are often used to complete the magnetic circuit, allowing maximum flux density though the air gap, with a minimum amount of permanent-magnet material. However, there are a considerable number of variations possible, either with or without pole pieces.

Our G-E magnet engineers have broad knowledge and experience in the design and construction of permanent magnets, pole pieces, and air gaps. They will be more than happy to share their knowledge with you. There is no obligation, and all information is held in strictest confidence. A letter to us will get them to work on your problem immediately.

And keep in mind the Carboloy products that perform a myriad of important jobs throughout industry: *cemented carbides* for combating wear; *Thermistors* for detection, measurement, and control of minute temperature variations; *Hevimet* for high-density and radioactive-shielding applications; and *vacuum-melted metals and alloys.*

"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

CARBOLOY
DEPARTMENT OF GENERAL ELECTRIC COMPANY
11126 E. 8 Mile Ave., Detroit 32, Michigan

CARBOLOY CREATED-METALS FOR INDUSTRIAL PROGRESS

—ITEM 176—
For More Information Circle Item Number on Yellow Card—page 19

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Our 56 years of specialized experience is part of every one of the millions of sleeve bearings we produce each year. It means that each of these bearings will meet the most exacting requirements of practically every type of automotive, industrial and agricultural equipment. We maintain complete facilities for research and engineering, and quality control in all of our plants.

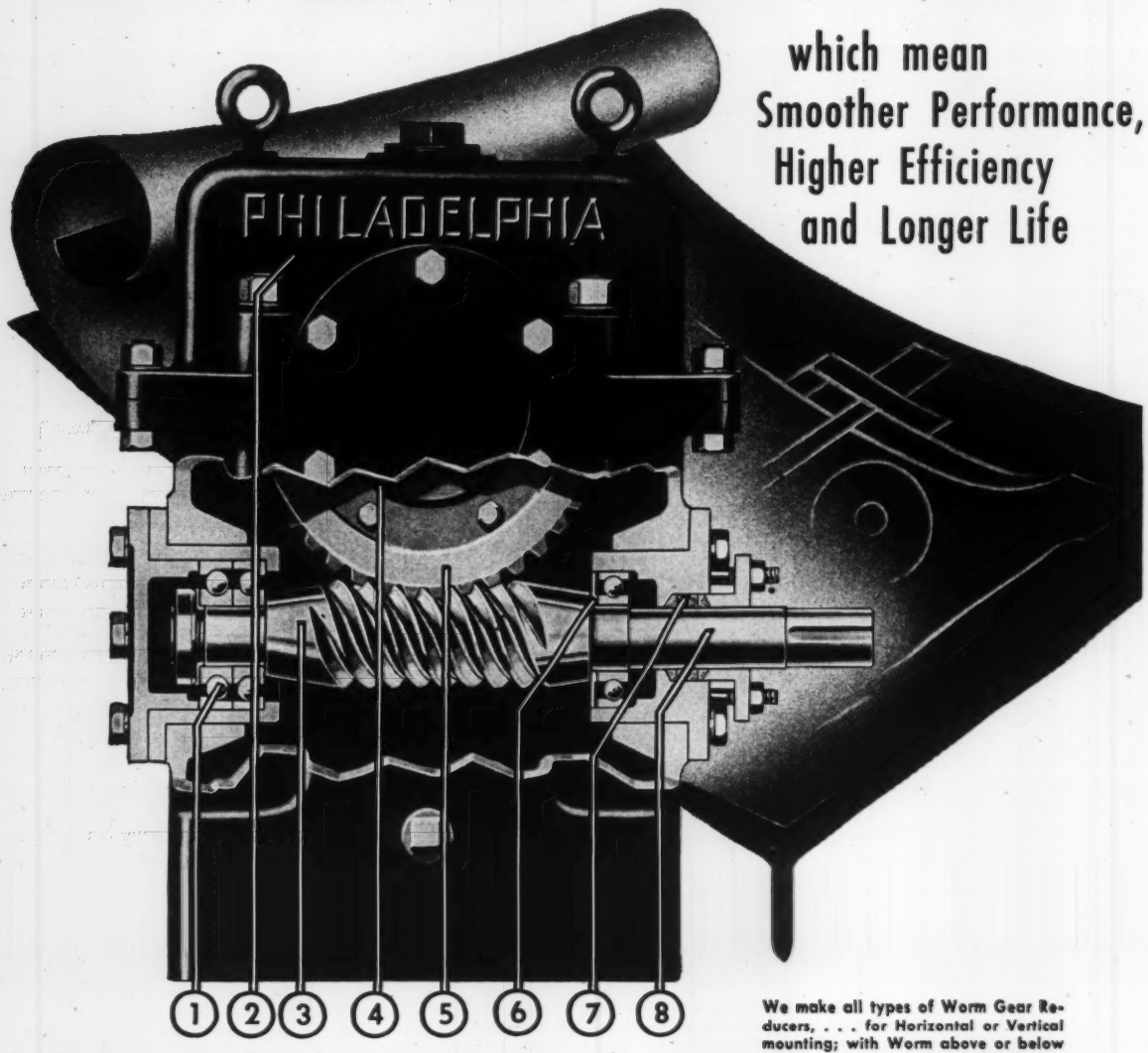
FEDERAL-MOGUL
DIVISION

FEDERAL Mogul
SINCE 1899

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

YOU GET ALL THESE ADVANTAGES...

which mean Smoother Performance, Higher Efficiency and Longer Life



1____ **BEARINGS** throughout are of highest quality, calculated to take all loads and stresses in accordance with maximum ratings of units.

2____ **EXCEPTIONALLY RIGID HOUSING** of best grade cast iron . . . Strengthening ribs integral with design.

3____ **WORMS** made of SAE 3115 Steel with carburized and hardened threads. Shaft and threads smoothly ground after hardening.

4____ **GEAR SHAFT BEARINGS** run in an oil well that automatically fills with fresh oil when filled from top. Splash from the gear keeps the wells filled to the overflow point.

5____ **WORM GEAR** made from quality chill cast nickel bronze bolted to a semi-steel center. (Smaller sizes are solid bronze.)

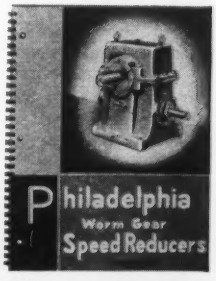
6____ **WORM AND WORM BEARINGS** run in oil bath. Baffle plates prevent flooding.

7____ **WORM SHAFT** equipped with stuffing box to prevent oil leakage.

8____ **SHAFTS** are premium quality. Always accurate, straight, concentric.

We make all types of Worm Gear Reducers, . . . for Horizontal or Vertical mounting; with Worm above or below Worm Gear; in Single, Double or Triple Reductions for medium or heavy duty service; any horsepower or reduction ratio.

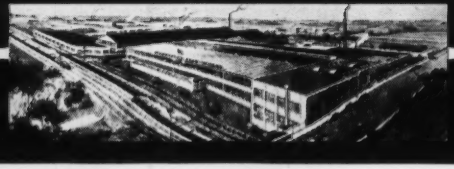
Tell us your Speed Reduction problems, and a Philadelphia Sales Engineer will gladly call upon you, . . . without obligation.



Catalog WG-51 sent upon request on your letterhead.

PHILADELPHIA GEAR WORKS, INC.

ERIE AVE. & G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.
BALTIMORE • CLEVELAND
Virginia Gear & Machine Corp. • Lynchburg, Va.



Industrial Gears & Speed Reducers

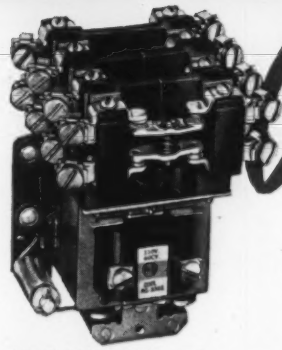
LimiTorque Valve Controls

Established 1892

—ITEM 178—

For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 179→

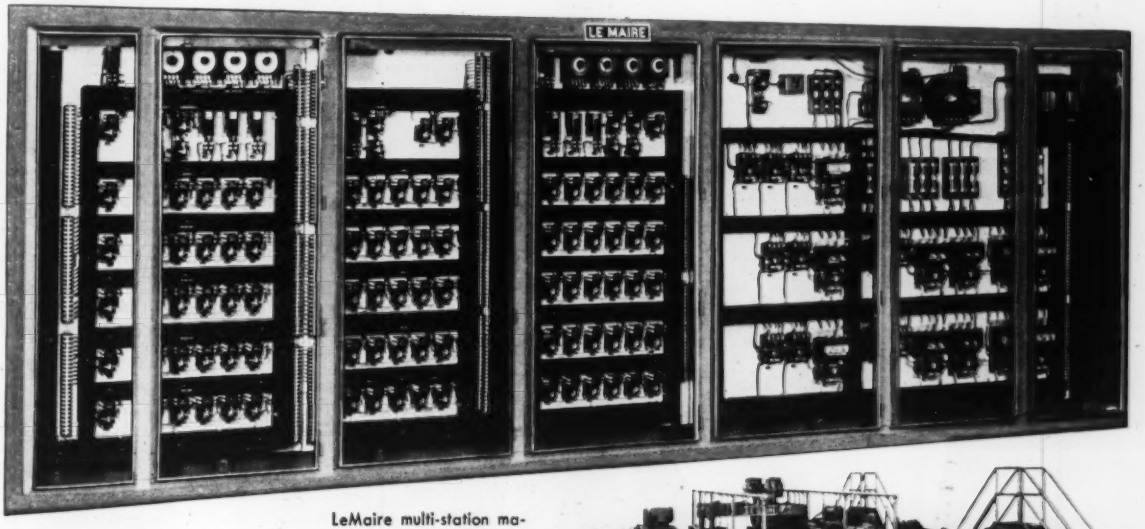


Bulletin 700 BX Universal relay with 4 normally open & normally closed contacts.

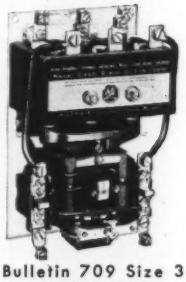
OVER 125 ALLEN-BRADLEY

RELAYS, TIMERS and STARTERS

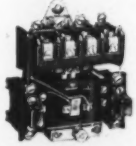
in this LEMAIRE Multiple Station Machine Panel



LeMaire multi-station machine operated by panel-board shown above. A good example of Allen-Bradley solenoid controls in the automotive industry.



Bulletin 709 Size 3 starter. Rated 30 hp, 220 v; 50 hp, 440-550 v.



Bulletin 709 Size 1 starter. Rated 5 hp, 220 v; 7½ hp, 440-550 v.

Bulletin 702 3-pole relay with magnetic hold-in latch. A hum-free relay.

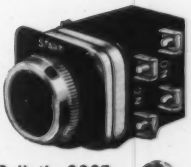
Did you notice the prominence of Allen-Bradley solenoid motor controls at the recent Chicago Machine Tool Show? Manufacturers recognize these reasons . . . the long, trouble free life of Allen-Bradley motor controls . . . their unerring precision in operation . . . the inherent QUALITY of their workmanship and materials.

Machinery manufacturers look to Allen-Bradley as a reliable source of control units and components. The A-B trademark is to them and their customers The Sign of QUALITY in Motor Controls.

Send for the Allen-Bradley Handy Catalog. It is a recognized handbook on motor control. Or, let our control specialists help you with your control problems.

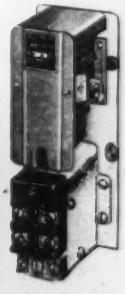
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
QUALITY



Bulletin 800T oiltight push button with NO & NC contacts.

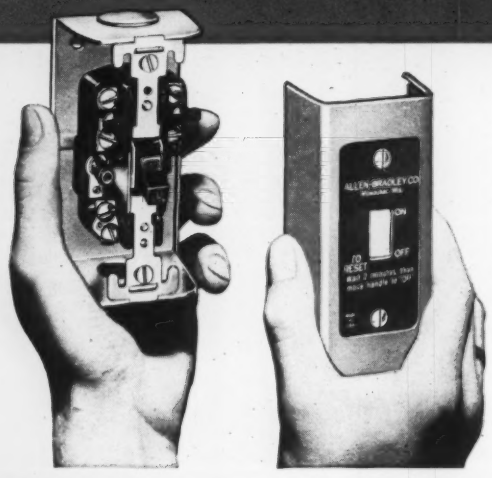
Bulletin 802T adjustable lever limit switch.

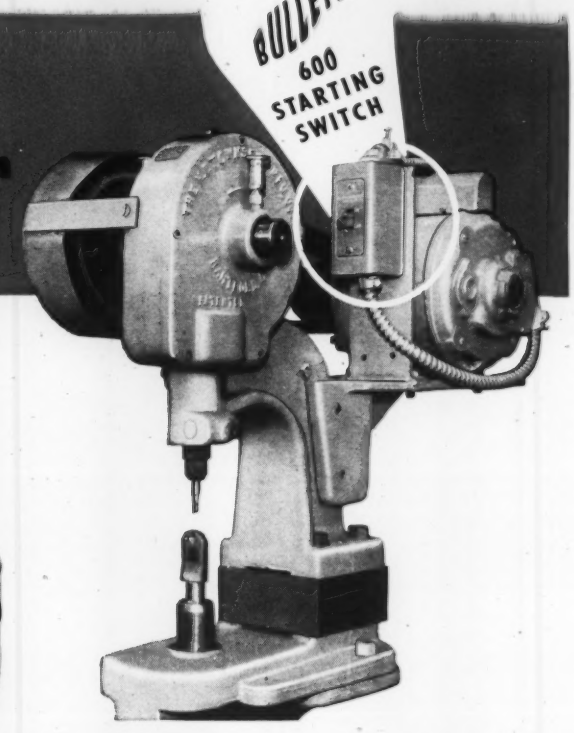


Bulletin 849 pneumatic timer—adjustable from 1/10 to 180 sec.

2-56-R

SMALL MOTORS
need overload protection too!





Because

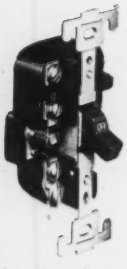
SMALL MOTORS CAN BE AS IMPORTANT TO PRODUCTION SCHEDULES AS LARGE MOTORS

Here is an outstandingly popular starter for applications using motors of ONE HORSEPOWER OR LESS.

It is a small, manually operated starter that is equipped with a time-tested, reliable A-B overload breaker. A soldered ratchet trips the operating lever in case of a sustained overload. It is reset, after tripping, merely by moving the operating lever to the OFF position. Overload heater elements are available to cover the ratings of this starter.

The Bulletin 600 starting switch is available in single and double pole construction. Its double break, silver alloy contacts provide high interrupting capacity. The contacts are always in good operating condition. They never need to be cleaned, filed or dressed. Please write for a copy of Bulletin 600 for complete information on the Bulletin 600 line.

SIMPLE DESIGN

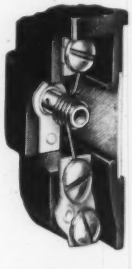


Simple ON & OFF snap switch . . . easy access to terminals . . . ample wiring space . . . silver alloy contacts need no cleaning or maintenance.

ATTRACTIVE APPEARANCE

Streamlined enclosure in grey enamel, and bonderized to assure positive binding of enamel finish to resist corrosion. The pilot light is optional.

OVERLOAD BREAKER

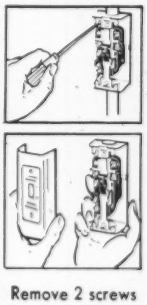


According to National Elec. Code ruling, motors of 1 hp or less, automatically started by thermostat, float switch, etc. must have overload protection.

FITS STANDARD SWITCH BOXES

Bulletin 600 starters fit any standard 2½ in. deep wall switch box. Can be mounted in machine frame or base. Available with pilot light.

EASY TO INSTALL

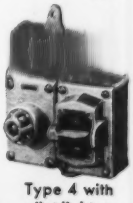


Remove 2 screws on front of starter slip off cover . . . attach conduit . . . pull in wires and connect to terminals . . . replace the cover.

VARIETY OF ENCLOSURES

Type 7 for hazardous locations.

Type 4 watertight.



Type 4 with pilot light.

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

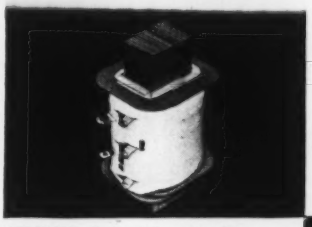
A-B Quality

ALLEN-BRADLEY

BULLETIN 600 STARTING SWITCHES

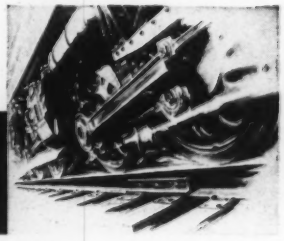
QUALITY

2-56-MR

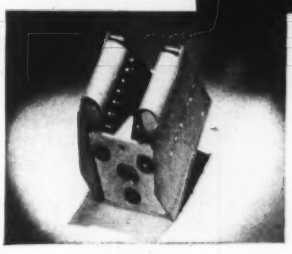


DIELECTRIC STRENGTH. National Vulcanized Fibre gives electrical parts high dielectric strength—plus toughness and excellent forming properties. Has ideal application as insulation.

NATIONAL VULCANIZED FIBRE



DURABLE—TOUGH—RUGGED. National Vulcanized Fibre rail joint insulation withstands years of continuous exposure and heavy pounding of today's high-speed railroading. Will not corrode or deteriorate.

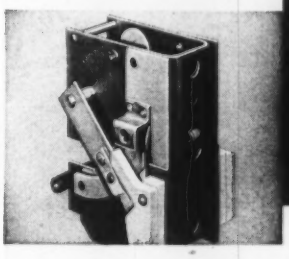


ARC RESISTANCE. In circuit breakers, National Vulcanized Fibre safely curbs electrical arcing without carbonizing or tracking. Easy to bend, punch and form. Light in weight. Heat-and-shock resistant.

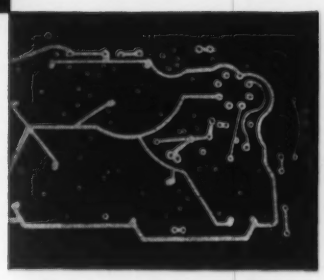
FOR MEN WITH IMAGINATION . . .

two materials of unlimited application

MACHINABILITY—MECHANICAL STRENGTH. New paper-base Phenolite not only has excellent arc resistance, but superior machining qualities as well. Great compressive and tensile strength.



CHEMICAL RESISTANCE. Chemical-resisting grades of Phenolite are unaffected by most corrosive fluids and atmospheres. Retain high strength, resiliency and dimensional stability.

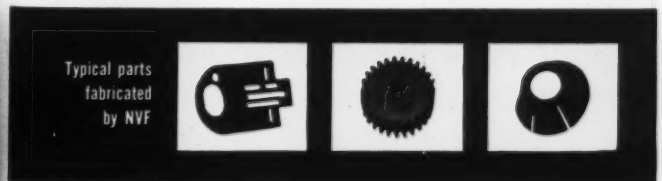


COMPACT DESIGN—ECONOMY—HIGH TEMPERATURE RESISTANCE. Printed circuits made of cooper-clad Phenolite permit compact design, simplify production, reduce assembly time.

Here are six ideas to spur your imagination. They only *suggest* the many things that can be done with National Vulcanized Fibre or Phenolite Laminated Plastic.

The full list of current uses for these materials would more than fill this page and many more pages! Yet more are coming up almost every day. For NVF is not only the world's largest producer of vulcanized fibre. We also make a fulltime job of thinking up new improvements to our products—and new ways of using them to improve *yours*. Result: designers call our materials the most versatile ever.

Looking for an easy, economical way to improve production—or products? Team up with NVF. We're prepared to assist you all the way from initial design to the delivery of precision fabricated parts. Our new 16-page Catalog will give you full information about our products and services. Write for it on your business letterhead to Dept G-2.



NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

In Canada: **National Fibre Company of Canada, Ltd.** • Toronto 3, Ont

Also Manufacturers of Peerless Insulation, Materials Handling Receptacles, Vul-Cot Wastebaskets and Textile Bobbins.

VISIT THE NATIONAL BOOTH—SPACE 777
IRE NATIONAL EXPOSITION MARCH 19-22 AT NEW YORK

—ITEM 180—
For More Information Circle Item Number on Yellow Card—page 19

Republic Stainless cuts cost of

Operator at left is removing scale accumulation from Clepco immersion heater casing made from Republic ELECTRUNITE® Stainless Steel Tubing. Any normal cleaning procedure may be followed without risk of damage to unit. And if your product demands cleanliness, the lustrous, smooth-finished surfaces of stainless tubing are clean, sanitary, and easy to keep that way. Solid stainless throughout, maintenance and replacement costs are reduced.

Operator at right is shaping 2″ Republic ELECTRUNITE Stainless Steel Tubing to a bullet nose by spinning it under flame. Workability of this tubing makes it easy to fabricate. For heater casings, Cleveland Process uses both Types 304 and 316 Stainless Tubing which they find highly satisfactory for either acid or alkaline solutions—at temperatures ranging from 100° to 600°.

REPUBLIC

REPUBLIC STEEL ®

World's Widest Range of Standard Steels

Tubing solves breakage problem...

Clepco immersion heater casings

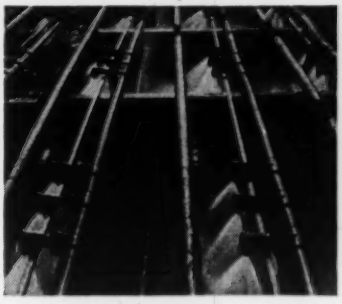
The Cleveland Process Company of Cleveland, Ohio, manufacturers of Clepco immersion heaters, had a twofold problem. The tube-like casings they use to house heating elements were fabricated from a brittle imported material. Scale removal was particularly hazardous—often resulting in a cracked or broken casing. Furthermore, the material itself, although an effective insulation, was expensive.

To solve these problems, Cleveland Process switched to Republic ELECTRUNITE Stainless Steel Tubing for heater casings. They found ELECTRUNITE Stainless Tubing easy to fabricate, having consistently uniform diameter, wall thickness, concentricity, strength and ductility. But most important, ELECTRUNITE completely eliminated breakage and substantially reduced material costs.

Made of long-lasting Republic ENDURO Stainless Steel, this tubing provides strong resistance to corrosion, oxidation and scaling at high temperatures. Where strength is a requirement ELECTRUNITE Stainless Tubing is ideal—providing an extremely high strength-to-weight ratio.

This tubing may be the very material you need to improve your product or process. For detailed information about the many cost-saving advantages of Republic ELECTRUNITE Stainless Steel Tubing—including sizes, gages and analyses—send coupon today for new, illustrated 60-page booklet.

REPUBLIC ENDURO® STAINLESS PIPE SAVES COSTS in paper mills. Section shown above is part of a piping system that conveys the highly corrosive pulp mixture to the processing machines. Where corrosion-resistance is vital to cost savings, the extra expense of this long-lasting piping is an inexpensive investment in long-range economy.



REPUBLIC SEMI-RIGID PLASTIC PIPE SAVES COSTS in cooling towers. Original pipe had to be replaced every four months in this cooling installation near coke ovens. A constant bath of corrosive steam saturated with hydrochloric acid soon destroyed it. Two years ago, Republic Semi-Rigid was installed with excellent results: no sign of damage to this date.

REPUBLIC DEKORON®-COATED EMT SAVES COSTS of electrical conduit in chemical plants. Wherever the atmosphere is corrosive, unprotected metal parts take a beating. But Dekoron-Coated EMT shrugs off corrosion. The tough, polyethylene coating over the galvanized finish gives double protection to electrical raceways. Send coupon for facts.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
3130 East 45th Street • Cleveland 27, Ohio

Please send me more information on:

- ☐ Republic ELECTRUNITE Stainless Steel Tubing
- ☐ Republic ENDURO Stainless Pipe
- ☐ Republic Plastic Pipe
- ☐ Republic Dekoron-Coated EMT

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

K-9699

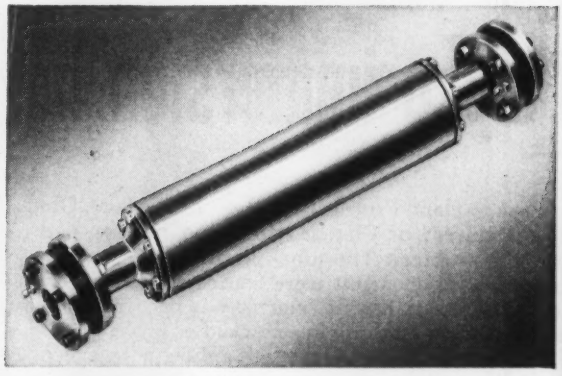
—ITEM 181—

For More Information Circle Item Number on Yellow Card—page 19

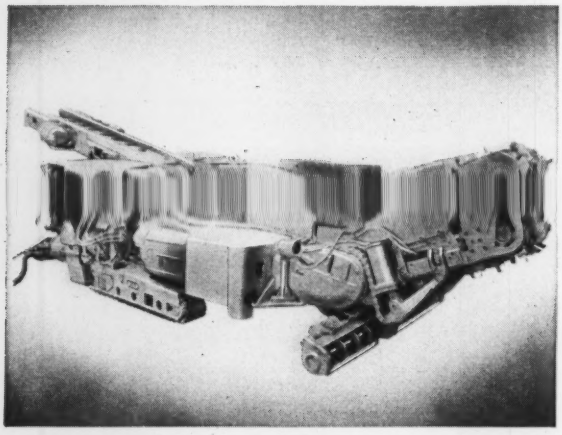
How Rzeppa Joints Solve Critical Drive Problems . . .

Changing or Fixed Angles – High or Low Speeds

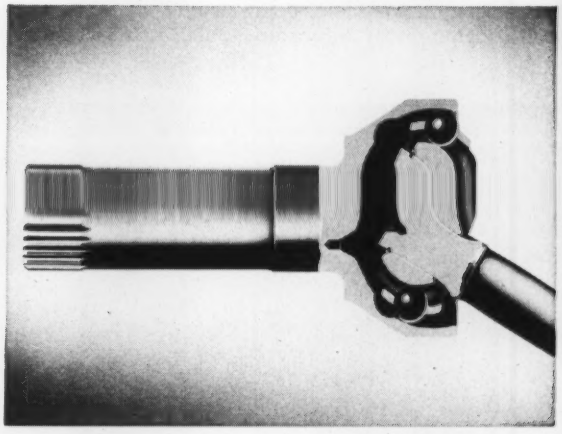
LOW ANGLE — HIGH SPEED Up to 3° at 8,000 rpm. Aircraft uses the Rzeppa disc type for auxiliary power take-off shaft drives because constant torques and speeds are transmitted. This type is especially adaptable to those applications where vibration is critical.



Rzeppa disc type joints are of rugged design. Are available in either spline-driven or bolt-driven types. A flexible neoprene seal permits working angles up to 18°.



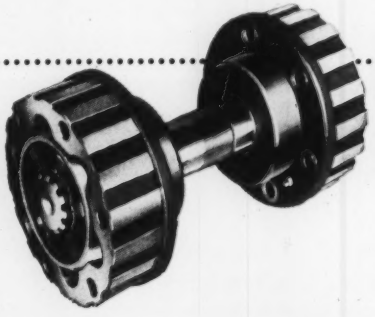
HIGH ANGLE — LOW SPEED Up to 35° at 400 rpm. Continuous miner really uses the versatility of Rzeppa bell type joints. Its working angle is constantly fluctuating. Bell joints are especially suited for power steering drives or articulated driving axles with independent wheel suspension.



Rzeppa bell type joints are constructed with a spline shank. Are easily sealed in axle housings or other machine components. Will handle working angles up to 35° depending on seal types and housings required.

Somewhere between the two applications shown lies the answer to more effective joint performance for you. Because of their versatility, Rzeppa Constant Velocity Universal Joints are transmitting a uniform flow of power in these and hundreds of other applications — including machine tools.

By transmitting true, constant rotating motion, Rzeppa Joints wear longer, have higher capacity, are more compact, and operate with less friction. That's why Rzeppa Joints carry heavier loads for their size than any other type. Disc type or bell type, you get ruggedness and versatility. Don't you, too, have an application that can use these performance advantages? Our catalog may help answer that for you. Send for it today.



TYPICAL DRIVE LINE APPLICATION – Jointed shaft for independently sprung rear axle and propeller shafts for industrial applications.

RZEPPA Constant Velocity **UNIVERSAL JOINTS**

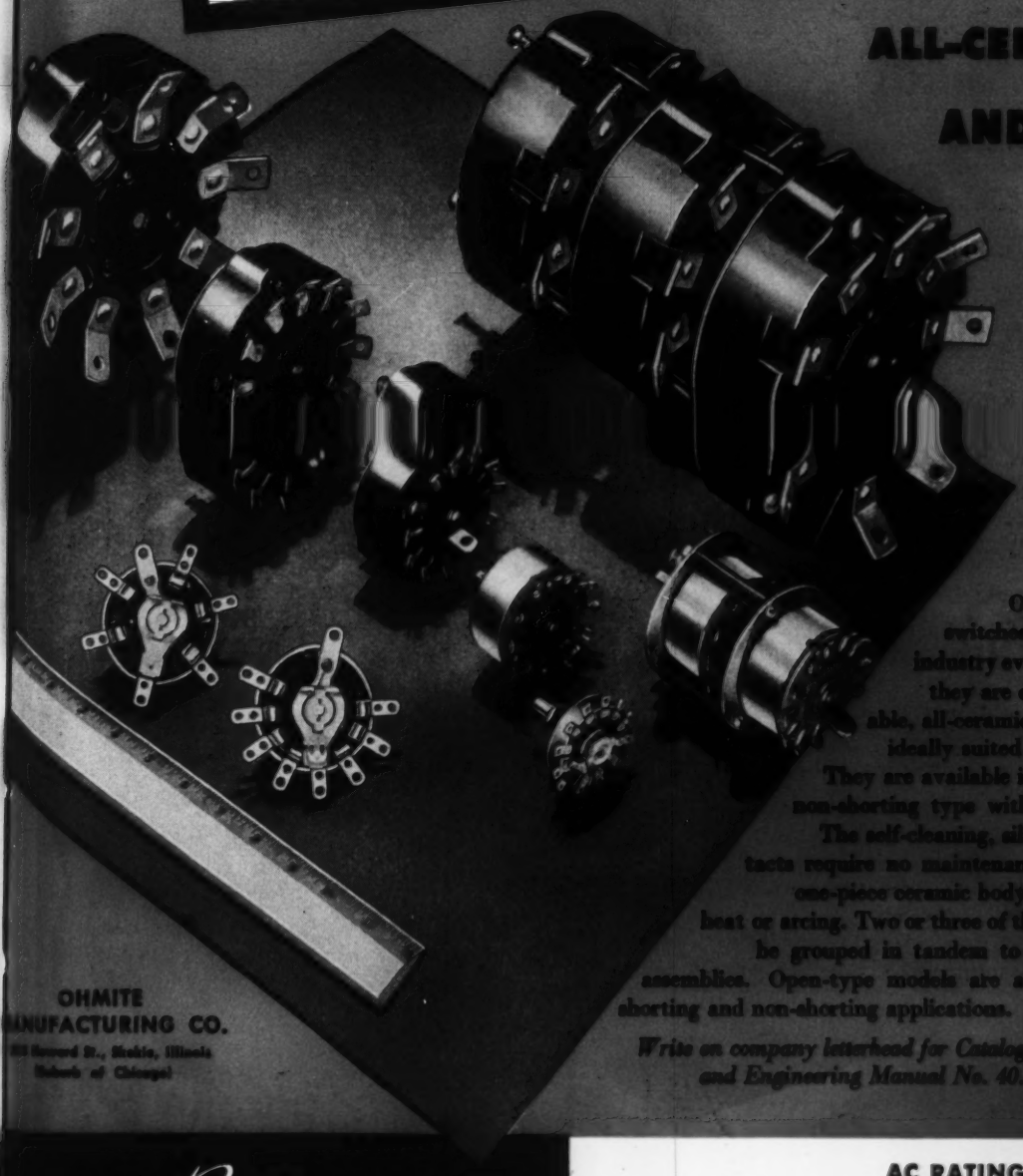
Joint Division
THE GEAR GRINDING MACHINE CO.
3937 Christopher, Detroit 11, Michigan

—ITEM 182—
For More Information Circle Item Number on Yellow Card—page 19
Facing Page—ITEM 183→

WON'T CHAR OR BURN!

OHMITE® HIGH CURRENT ROTARY TAP SWITCHES

ALL-CERAMIC AND METAL



Ohmite rotary tap switches are preferred by industry everywhere because they are compact, dependable, all-ceramic and metal units ideally suited to a-c operation. They are available in the single-pole, non-shorting type with up to 12 taps. The self-cleaning, silver-to-silver contacts require no maintenance. The rugged, one-piece ceramic body is unaffected by heat or arcing. Two or three of these switches can be grouped in tandem to form multi-pole assemblies. Open-type models are also available for shorting and non-shorting applications.

Write on company letterhead for Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING CO.
[illegible] Howard St., Skokie, Illinois
Suburb of Chicago

Be Right with

OHMITE®

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES

5 SIZES

AC RATINGS

AMP	VOLTS	NO. TAPS
10	150	2 to 11
15	150	2 to 12
25	300*	2 to 12
50	300*	2 to 12
100	300	2 to 8

*150 Volts between taps.

Here it is . . . !

THE NEW "48-FRAME" THAT GIVES YOU Century

MOTOR DESIGN
INDUSTRIAL QUALITY

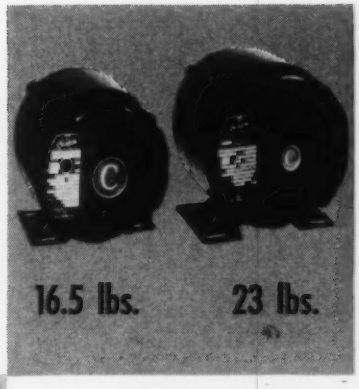
Everything you asked for and more. Smaller, yes . . . and better, too. Here is traditional Century dependability, smooth-running and quietness under load . . . now skillfully engineered into the compact new "48-Frame" design.

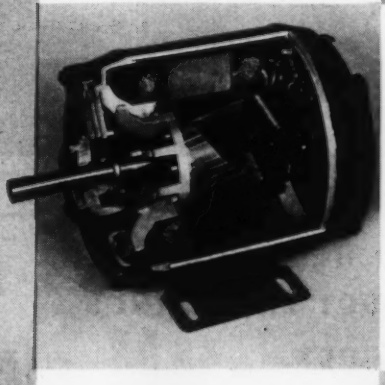
These great new Century "Industrial Quality" motors are now available in sizes from 1/20 to 1/3 H.P. . . . . developed specially for industrial users.

SEE A SAMPLE of the New Century "48-Frame" motor . . . test one in your plant. Your Century representative will be glad to show you a graphic point-by-point comparison to answer any specific questions you might have. Let him show you how the smaller, lighter and *better* new Century "48-Frame" design gives you true *industrial* quality. Call or write your nearby Century District Sales Office or Authorized Distributor.

We Invite Your Comparison of...

engineering—Weight savings up to one-third are made possible without "skimping" on the vital "active materials," simply by eliminating dead weight and using new materials. The result is smaller-diameter motors that are not merely "just as good" but actually superior to the famous Century "56-Frame."





compare design—For time-saving maintenance, "GITS"-type oilers for sleeve bearings are placed high on the end-brackets, allowing easy oiling from either end of the motor . . . cluster-type integrally cast fan at the rear end of the rotor draws a steady stream of cooling air over the coilheads . . . "Square" stator iron permits air to pass between the core and shell, cooling the whole width.

compare materials—Genuine bonded "MYLAR" slot insulation is used . . . wound cores are dipped and baked in thermosetting insulating varnish . . . GLASTIC high arc resistance switch-mounting plate . . . light and strong, *stress-relieved* pressure-cast aluminum end-brackets, which machine true and *stay* true.

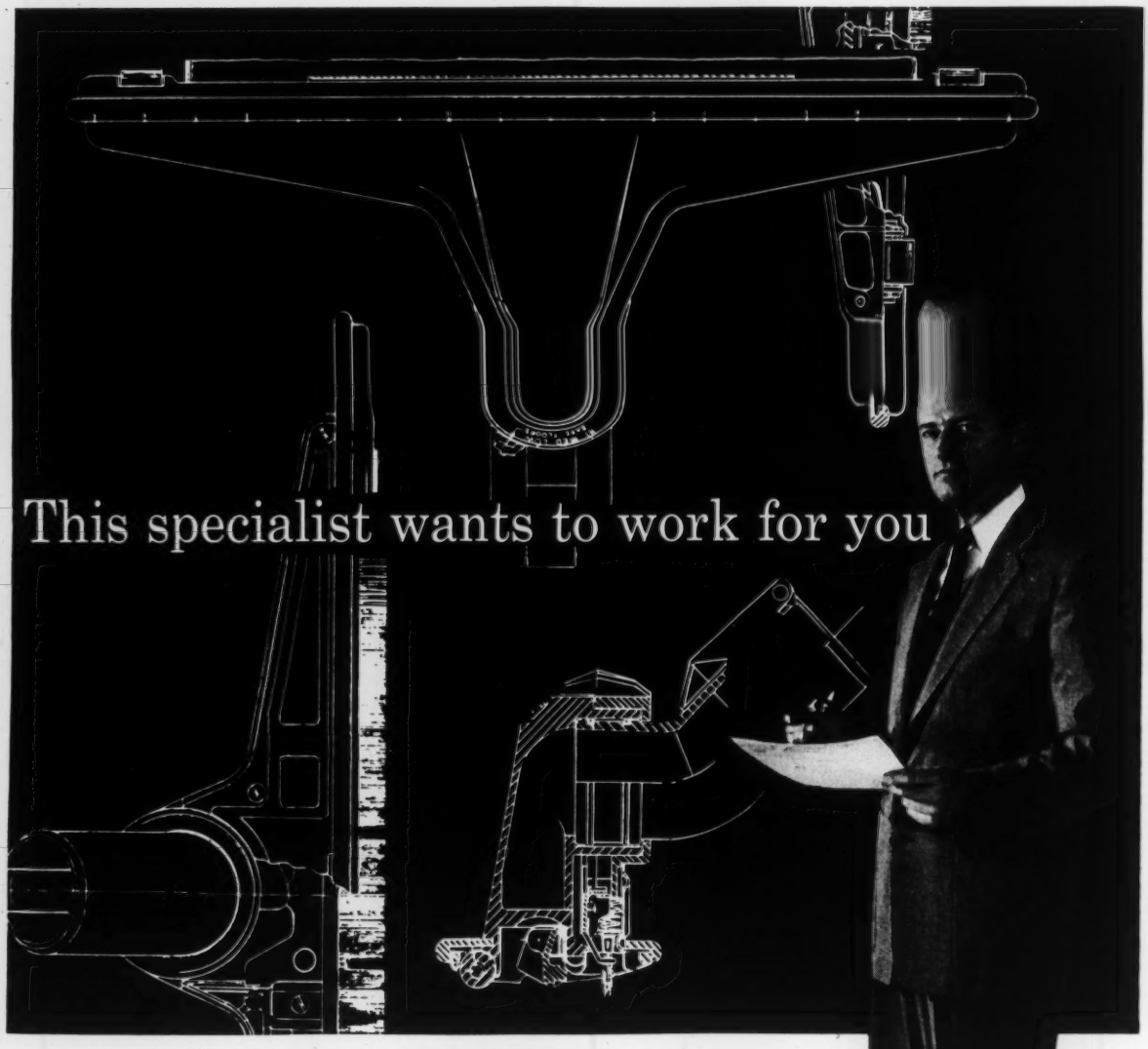
-55

Performance Rated©
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

—ITEM 184—
For More Information Circle Item Number on Yellow Card—page 19



P-K® ASSEMBLY ENGINEERS ARE TRAINED TO HELP YOU DESIGN BETTER PRODUCT FASTENINGS AT LOWER COST

There's a Parker-Kalon Assembly Engineer nearby—ready to work for you. He's a fastener specialist with the experience and skill to help with your particular problem. Perhaps, he can show you how to eliminate some fasteners from your design—or suggest the use of less expensive types of fasteners. That's part of his job. Take advantage of this unique service while your product is still in the design stage. Call your local Parker-Kalon distributor and have him send a P-K assembly engineer to your office. This service is another reason why industry finds... if it's P-K, it's O.K.!

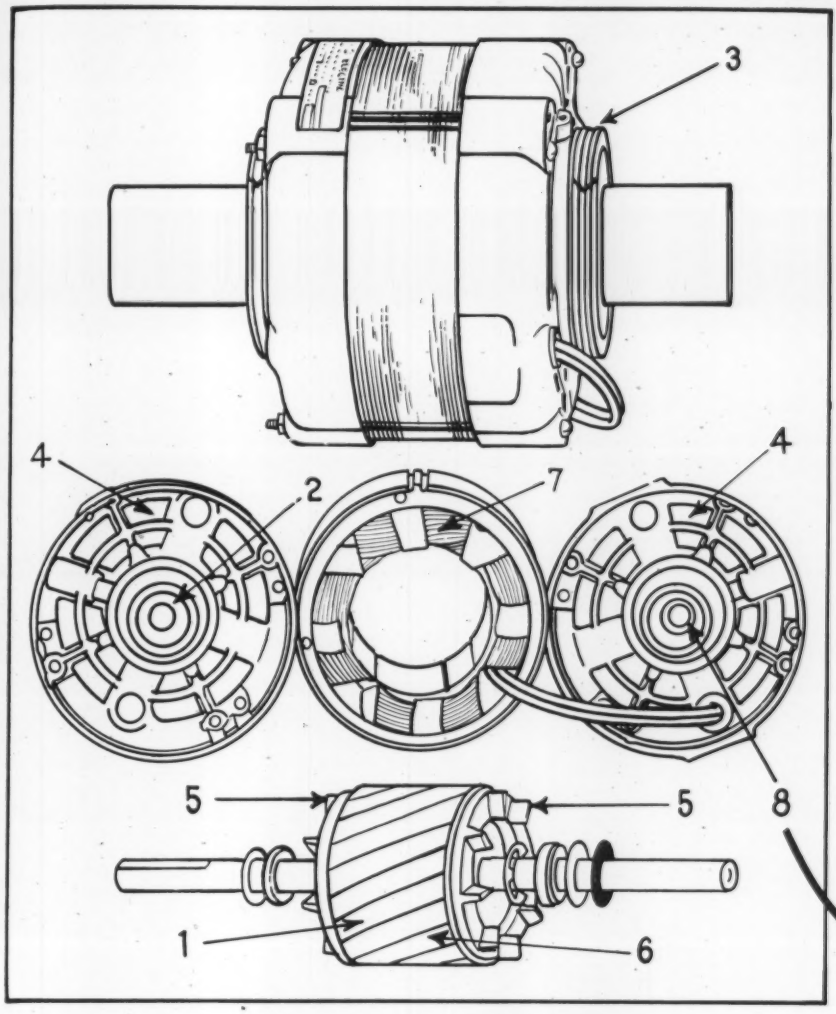
Sold Everywhere Through Leading Industrial Distributors. Warehouses in Chicago, Illinois, Los Angeles, California

PARKER-KALON® *fasteners*

PARKER-KALON DIVISION • GENERAL AMERICAN TRANSPORTATION CORPORATION • CLIFTON, NEW JERSEY

—ITEM 185—
For More Information Circle Item Number on Yellow Card—page 19

New...for ECONOMICAL drives



Quiet Operation!

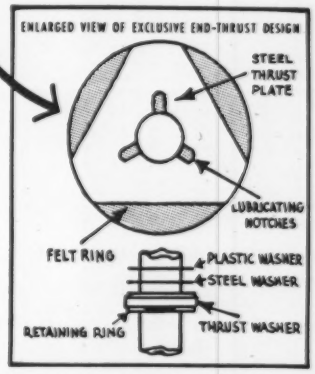
1. Full-skew rotor design. Carefully controlled maximum skew eliminates electrical and magnetic noises.
2. Two large ½-inch diameter bearings assure many years of quiet operation.
3. Special low-durometer-hardness, oil-resistant, synthetic-rubber mounting rings on all resilient mountings kill vibration noises.

Cool Operation!

4. Wide, open end-shields permit free circulation of cool air over windings.
5. Double-fan rotor design gives individual cooling to the end coils. Air enters both ends of motor, giving uniform, efficient cooling.

Highest Performance!

6. Indestructible die-cast rotor is heat-treated to increase electrical efficiency. Full-skew rotor design gives smooth, steady starting and operating torque.
7. Insulation is specially designed to withstand high humidity conditions.
8. Exclusive end-thrust design provides smooth, quiet operation and long, trouble-free motor life.



Apertures in the steel thrust plate permit lubricant from felt ring to be carried to thrust surface. Longer continuous operating life is assured.

Emerson-Electric Shaded-pole Motors

40 MHP; 1/20, 1/15, 1/12, 1/10, 1/8 HP

Wherever economy is a factor, these new Emerson-Electric Shaded-pole Motors are particularly recommended. They are noted for their quiet, cool operation and long, trouble-free life—are suited to such drives as air-conditioner fans, air circulators, unit heaters, air humidifiers, evaporative coolers, window fans, kitchen ventilators, displays.

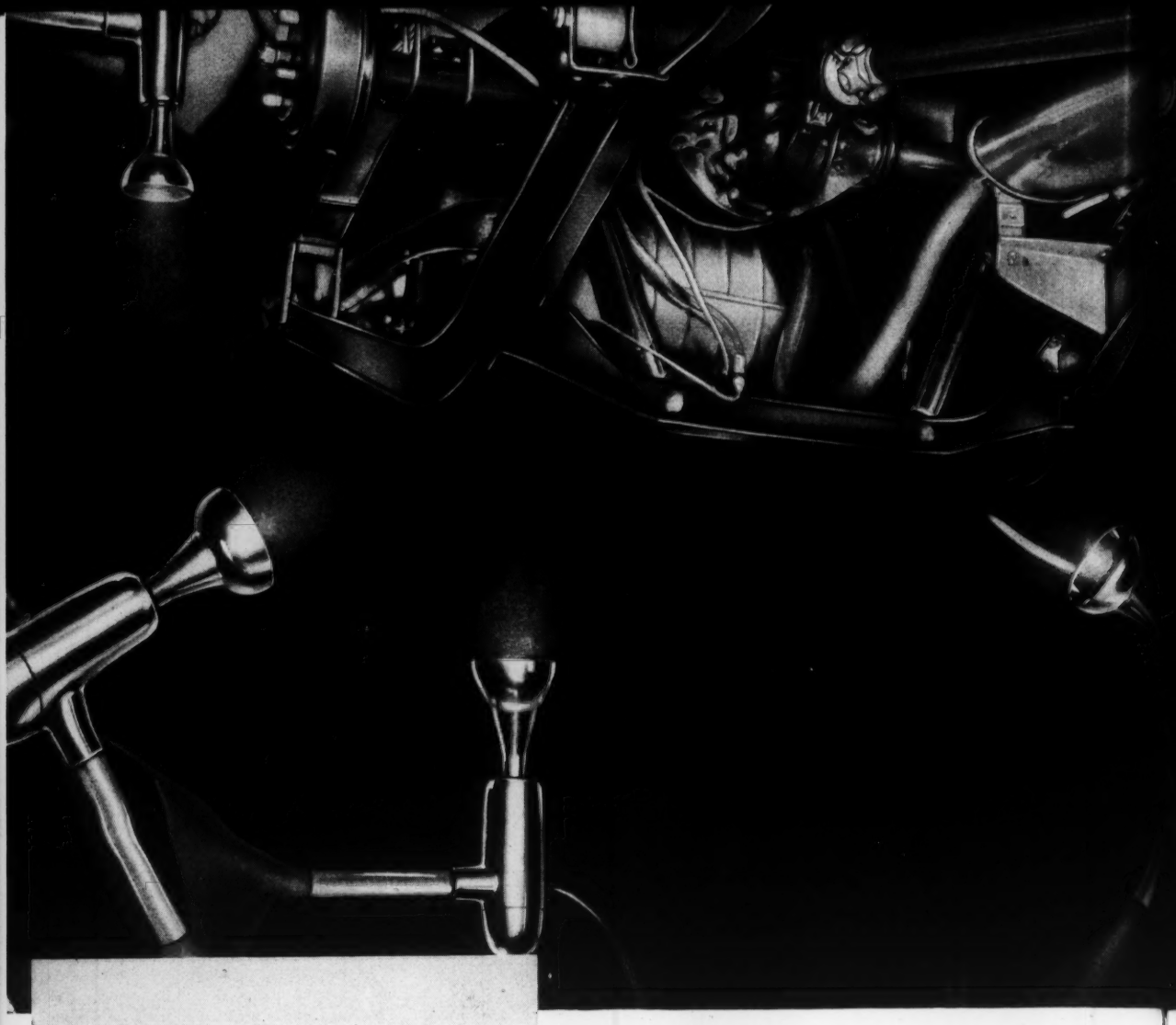
Among many features that distinguish these new motors is Emerson-Electric's *exclusive* thrust provision which minimizes wear and reduces end play, preventing undesirable noise and variable operation, after the motor is in service. See illustration.

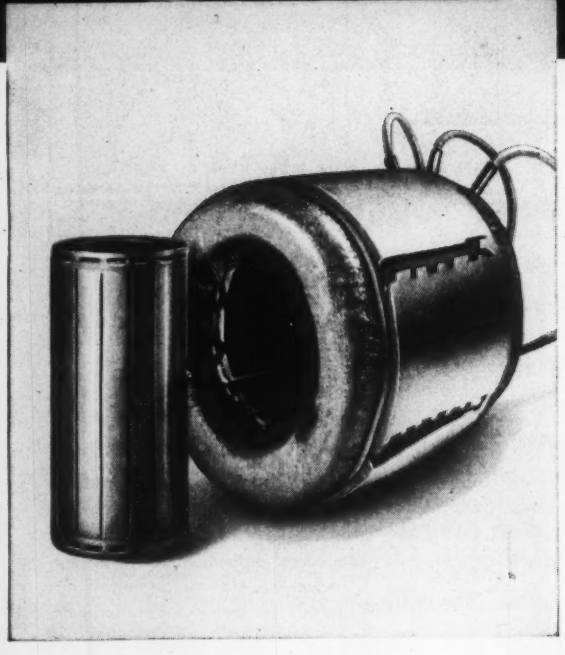
Get More Information

For more information on these new Shaded-pole Motors, call an Emerson Electric motor-drive specialist or write for Bulletin No. M 21. THE EMERSON ELECTRIC MFG. CO., ST. LOUIS 21, MO.

Since 1890 **Emerson-Electric** *of St. Louis*

Branches: NEW YORK 7, N. Y., 11 Park Place • CHICAGO 23, ILL., 1623 S. Pulaski Road • SYRACUSE, N. Y., 209 Oakley Drive • PHILADELPHIA (Secane), PA., 868 Quince Lane • DETROIT 7, MICH., 1375 E. Jefferson Ave. CLEVELAND 16, OHIO, 1580 Rockland Ave. • LOS ANGELES 42, CALIF., 5415 York Blvd. • DAVENPORT, IOWA, 617 Brady St. • CINCINNATI 11, OHIO, 2917 Ratterman Ave.





R&M MOTOR PARTS AT WORK

A prominent passenger car manufacturer gets eleven times more chassis per gallon—reducing paint and production costs substantially—with the efficient, high-quality electrostatic paint spray process of the Ransburg Electro-Coating Corp., Indianapolis, Ind. Robbins & Myers polyphase motor parts are utilized to atomize the paint spray in an electrostatic field. The spray is attracted to the products, which are grounded through the hanger, producing a high degree of uniformity of finish.

Rugged rotor and stator for a polyphase portable tool. The rotor consists of squirrel cage, embedded in laminated core with bars and end rings of copper, brazed or welded together. The stator has a high-grade silicon steel core with top-quality rag paper used to insulate the coil from the core. The finished winding is taped and thoroughly impregnated with high-grade synthetic resin base varnish to assure trouble-free operation with minimum danger of short circuits and grounds.

ROBBINS & MYERS, INC.

MOTOR DIVISION: SPRINGFIELD 99, OHIO • BRANTFORD, ONTARIO

Fractional & Integral h.p. Motors & Generators

Household Fans

Electric & Hand Hoists & Cranes

Moyno Pumps

Propellair Industrial Ventilating Equipment

R & M SPECIALISTS INTEGRATE MOTOR AND MACHINE DESIGNS... TO ASSURE HIGHEST PERFORMANCE

Many factors must be considered in designing a new motor-operated product that will perform its intended functions accurately, economically, and with a low maintenance and failure rate. Much depends on the proper correlation and integration of motor and machine designs. A special knowledge of motor application can be valuable to you. Robbins & Myers motor design specialists can help you solve these problems, to whatever extent you desire.

The exact motor for your machine is worked out quickly and accurately, with systematic methods of designing motors. This might include, for example, the use of R & M's unique "Electrical Slide Rule." Electrical equivalents can be set up on the slide rule to simulate the conditions under which the motor must operate in your product. By this method we are able to investigate hundreds of different design possibilities, assuring the best motor for the job.

In some cases the answers point to a standard motor. And here, R & M offers a wide variety of types and sizes of complete motors or matched motor parts.

In other cases special motors are indicated. R & M is equipped to do a fast, thorough, economical job of custom-designing a motor that's exactly right for your product.

Don't settle for an "off-the-shelf" compromise. Standard or custom-designed, R & M will get you the right answer quickly —with no obligation!

R & M MOTORS AND MOTOR PARTS POWER MANY TYPES OF EQUIPMENT, SUCH AS . . .

Portable Saws	Routers	Nut Setters	Hedge Trimmers
Drills	Screw Drivers	Hammers	Lawn Mowers
Nibblers	Pumps	Polishers	Oil Burners
Lock Mortisers	Compressors	Planers	Surgical Instruments
Valve Grinders	Hones	Portable Grinders	Grease Guns
Vacuum Cleaners	Business Machines	Sirens	Vibrators
Fans	Cast Cutters	Advertising Devices	Die Sinkers
Sanders	Food Mixers	Ventilating Equipment	Waxers

R&M MAKES BOTH!

Fractional-horsepower motors and parts . . . from 1/200 h.p.

If it's an R&M, it's the Right Motor!

Integral-horsepower motors; famous R&M "All-Weather"* with sealed bearings. Up to 200 h.p.

*"All-Weather" is an R & M trademark

This coupon will bring you prompt information. MD

Robbins & Myers, Inc., Motor Division, Springfield 99, Ohio

Please send me, without obligation, information on:

- ☐ Motor Parts for Portable Tools
- ☐ Universal Motors
- ☐ Capacitor Motors
- ☐ R & M "All-Weather" Motors —up to 200 h.p.
- ☐ Please have a Motor Specialist call

Product we manufacture: _____

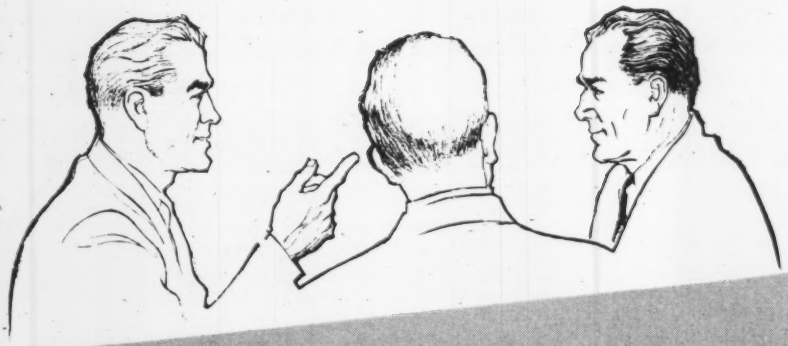
Name _____

Title _____

Company _____

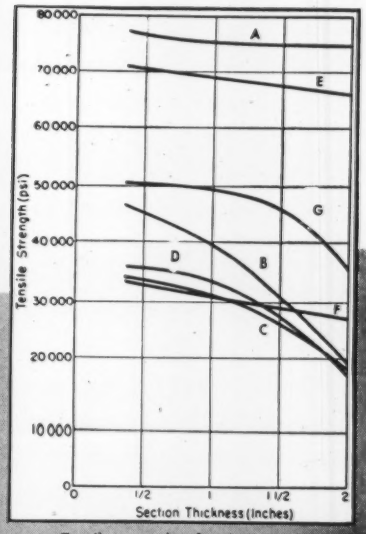
Street _____

City & State _____

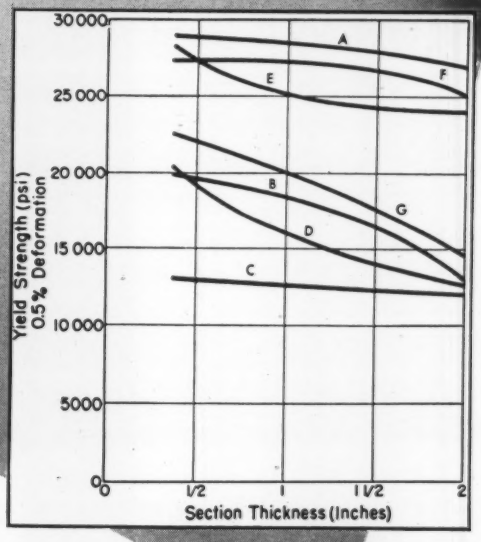


Here's proof....

that you can use lighter sections, have greater strength, improve your product, save money with AMPCO* Metal



Tensile strengths of various non-ferrous metals vs. section thickness



Yield strengths of various non-ferrous metals vs. section thickness

Examine these charts carefully — they tell a story that can save you money and put extra life and dependability into your product.

Look, for instance, how other non-ferrous metals show a sharp decrease in mechanical values as casting cross-sections increase. Ampco remains practically constant — you require less metal.

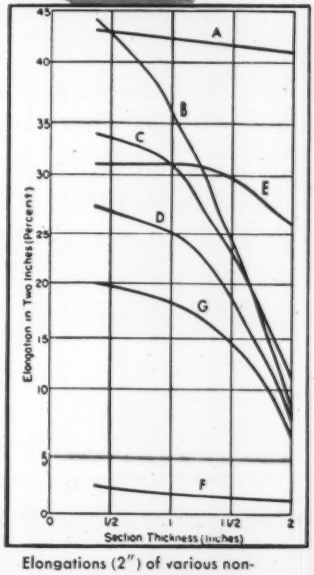
Note Ampco's unusually high tensile and yield strengths compared with conventional bronzes — you use lighter sections to do a better job. And Ampco Metal weighs 10 to 15 percent less than other bronzes — so you can make important weight reductions

Fact is, Ampco Metal's high strength-to-weight ratios can mean real savings for you — savings in material and money. Consult your nearby Ampco field engineer for full information or write us.

CHART REFERENCE

- A. Ampco Metal
- B. Tin Bronze (88-8-4)
- C. Red Brass
- D. Tin Bronze (85-5-5-5)
- E. Manganese Bronze
- F. Aluminum Alloy
- G. Silicon Bronze

Charts courtesy Materials & Methods and Westinghouse Electric Corp



Elongations (2") of various non-ferrous metals vs section thickness

AMPCO®

Sole Producer of Genuine Ampco Metal

AMPCO METAL, INC.

Dept. MD-2, Milwaukee 46, Wisconsin

West Coast Plant: BURBANK, CALIFORNIA

*Reg U S Pat Off

D-43

—ITEM 188—

For More Information Circle Item Number on Yellow Card—page 19

60 second tour

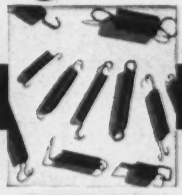
shows it in a nutshell . . .

All-Inclusive Spring Service

COMPRESSION SPRINGS
Regular, Double

COMPRESSION SPRINGS
Special Shapes
Variable pitch

VOLUTE SPRINGS
Coned end



EXTENSION SPRINGS
Special Hooks
and Loops

EXTENSION SPRINGS
Swivel End
Drawbar

TORSION SPRINGS
Single, double
Edge wound

POWER SPRINGS
Clock or Motor

FLAT SPRINGS
Arched, Curved-beam
Elliptical

CLIPS, CLAMPS
and COLLARS

FASTENERS and
RETAINERS

HAIRSPRINGS
for Instruments
Gauges, etc.

SPRING WASHERS
Wavy, Star, Finger,
Expander, etc.

BELLEVILLE SPRINGS
In Series, Parallel
Parallel-series

DIAPHRAGMS
Discs, Plates

PLUS
COLD-ROLLED
SPRING STEEL

WALLACE BARNES COMPANY
BRISTOL, CONNECTICUT

THE WILLIAM D. GIBSON COMPANY
1800 CLYBOURN AVE.
CHICAGO 14, ILL.

RAYMOND Manufacturing COMPANY
CORRY, PENNSYLVANIA

BARNES-GIBSON-RAYMOND
40300 PLYMOUTH RD.
PLYMOUTH, MICH.

B-G-R COOK PLANT
ANN ARBOR
MICHIGAN

SEABOARD Coil Spring Div.
15001 S. BROADWAY
GARDENA, CALIF.

OHIO DIVISION
1825 EAST FIRST ST.
DAYTON, OHIO

WALLACE BARNES COMPANY
STATE FAIR BLVD.
SYRACUSE 9 (Salina), N.Y.

MILWAUKEE DIVISION
341 E. ERIE ST.
MILWAUKEE, WIS.

DUNBAR BROTHERS COMPANY
BRISTOL, CONN.

F. N. MAHROSS AND SONS CO.
BRISTOL
CONNECTICUT

THE WALLACE BARNES CO., LTD.
HAMILTON
CANADA

Divisions of

ASSOCIATED SPRING CORPORATION

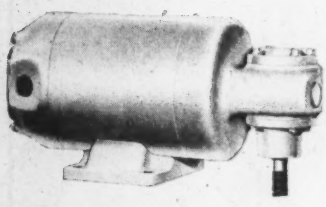
when you need a *Special* motor...contact DOERR

Over 95% of Doerr's production consists of motors with one or more special features

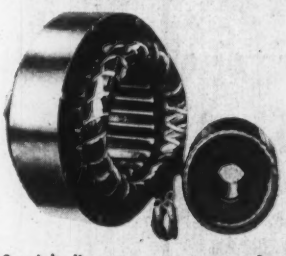
Rely on Doerr's long and specialized experience to solve your problems. List your specifications. Then let Doerr prove how easy it is to select and receive on-time delivery of motors that *exactly* fill your need.

Special features and modifications of all types are available. Present castings, windings and mountings can be adapted to solve new design problems at minimum cost. In addition, Doerr makes a complete line of standard NEMA ratings, every motor precision-built to the highest standards of quality.

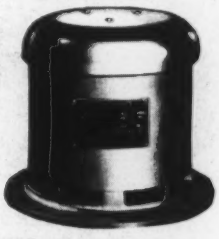
Discover now why leading machinery builders consistently re-order Doerr Motors. Before you buy, just write or call us in for a talk. More than likely we can furnish the top-quality power package you want.



Gearmotor for agitator drive on bulk milk cooler. Stainless steel shaft. Leak-proof seal.

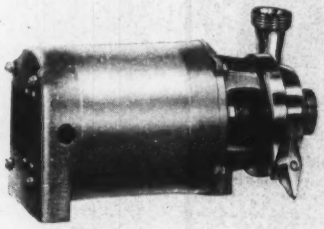


Special diameter motor parts for use in rotary oil burners. Range ½ to 5 HP.

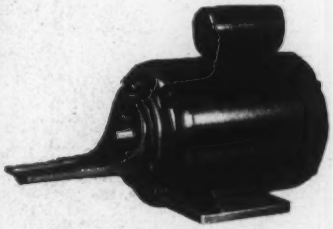


Floor machine motor. Low contour—high torques—pleasing appearance.

Doerr motor with special mounting used on leading 10" tilting arbor saw.



Sanitary dairy pump motor . . . Doerr-Designed to customer's specifications.



Special pump bracket eliminates mounting and alignment problems. Saves space and weight.

Special and standard electric motors from 1/30 to 5 HP that exactly meet your needs.

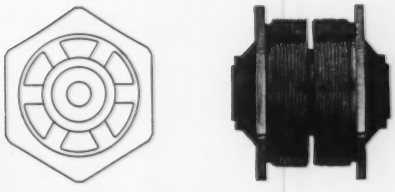
You Get MORE with Doerr!

Write for New Bulletin on Electric Motors Without Obligation

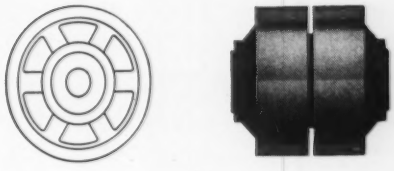
DOERR
Electric Corporation
CEDARBURG, WISCONSIN

—ITEM 190—
For More Information Circle Item Number on Yellow Card—page 19

Special MB mounts give damped vibration control



Threaded flange or press-in types available in MB damped vibration isolators.

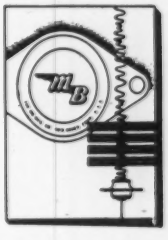


What to do when low frequencies cause resonance in vibration isolators? That was the problem put to MB engineers by one company. Stiffer mounts had been tried. But these reduced isolation of higher frequency vibrations and caused malfunctioning of the sensitive product.

New, type 121 MB mounts supplied the answer. These units minimize low frequency resonances through a unique internal damping design without any sacrifice of high frequency isolating efficiency. They restrict resonant build-up to below 3.5 to 1 *in any direction of vibration.*

Three sizes are now available to you, in threaded or press-in types. All meet military specifications on vibration and shock. Metal parts interlock, totally enclosing and protecting damper. Load ranges: from 15 to 100 pounds per unit.

Satisfying special vibration control needs has been MB's business for over 15 years. Take advantage of this fund of busy and successful experience. Check with MB for special-performance mounts available as standard units.



BULLETIN NO. 616 gives useful, helpful data on vibration. Send for your copy to Dept. 3

MB *manufacturing company* 1060 State Street, New Haven 11, Conn.

A division of Textron American, Inc.

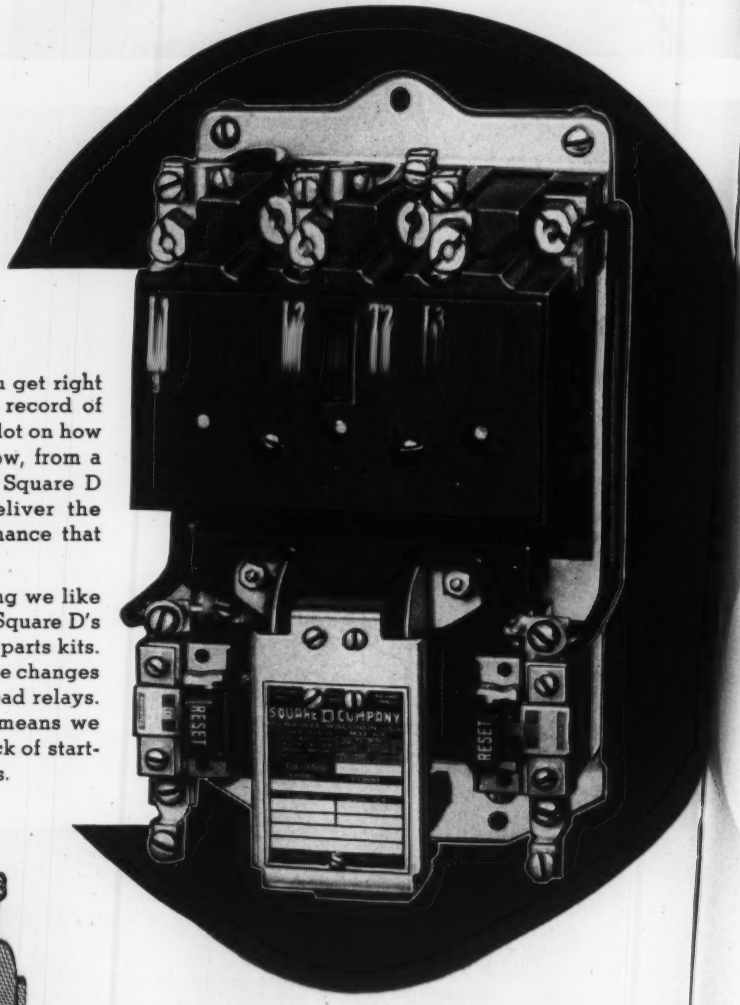
PRODUCTS TO ISOLATE VIBRATION . . . TO EXCITE VIBRATION . . . TO MEASURE VIBRATION

—ITEM 191—

Next Page—ITEM 192→

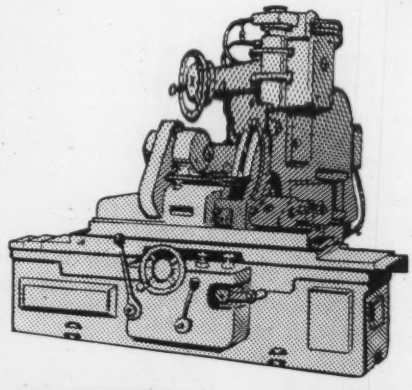
For More Information Circle Item Number on Yellow Card—page 19

Here's Why We Use SQUARE D Starters on the Machines We BUILD



PERFORMANCE When you get right down to it, the performance record of any machine tool depends a lot on how the control behaves. We know, from a lot of past experience, that Square D starters are designed to deliver the kind of trouble-free performance that keeps our customers happy.

FLEXIBILITY Another thing we like is the flexibility we get with Square D's starter design with packaged parts kits. It's a cinch to make last-minute changes in interlocks, coils and overload relays. That's important because it means we don't have to keep a big stock of starters with a lot of modifications.



FIELD ENGINEERING SERVICE

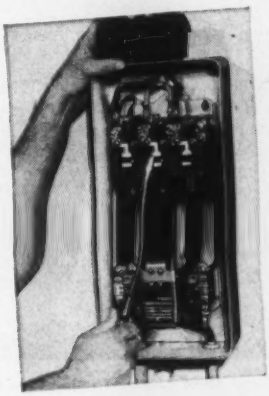
When we're designing machines that call for more complicated electrical control, it's mighty nice to have a Square D Field Engineer handy to work with us. As a matter of fact, he'll carry the ball just as far as we say—even to developing the control circuit for a multi-station machine.

SQUARE D COMPANY

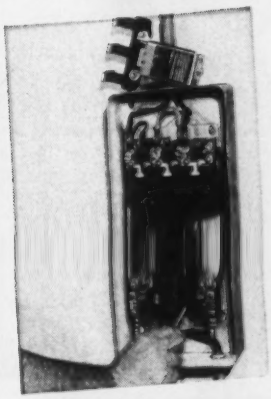
Here's Why We Specify
SQUARE D Starters
on the Machinery We BUY

PERFORMANCE, EASY INSPECTION AND MAINTENANCE

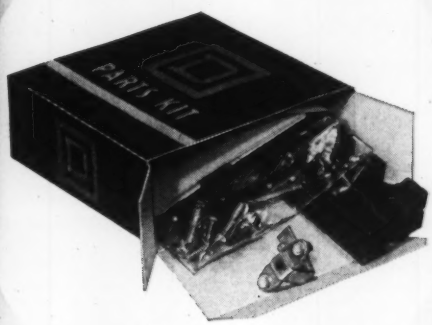
Sure, we like Square D performance because it keeps our "down time" at a minimum. BUT—everybody knows that even the best starter needs periodic inspection and preventive maintenance. We like the way Square D makes it easy to handle those routine jobs.



1 Loosen two screws and the arc chamber cover comes off. Every contact surface can be inspected at a glance.

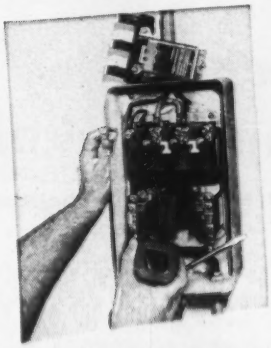


2 Remove four screws and entire movable assembly can be lifted off. Disconnect two wires and slip off magnet coil.

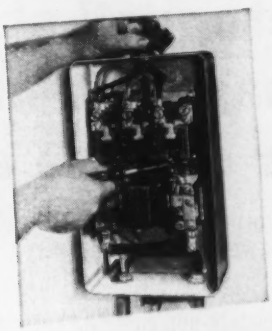


OFF-THE-SHELF PARTS KITS

They make normal maintenance and modifications easier than ever. Packaged parts include interlocks, contacts, coils, overload relays, pushbuttons and selector switches. They're easy to buy, easy to identify, and faster to install.



3 Contacts are attached with separate screws—they can be removed and replaced without disturbing any wiring. A screwdriver is the only tool needed.



4 Sizes 0 through 4 starters have these separate mounting electrical interlocks for easier installation. Contact block is attached from front of panel with two screws.

Everybody's Ahead with Square D!

9½ Pound Magnetic Octopus, about 12" square, primarily designed for dip tank use in hot or corrosive liquids, as shown. Utilizing Alnico magnets in 3 small stainless steel (18-8) tubes, it retrieves tools, tramp iron and tiny iron particles from hard-to-reach bottoms of ovens, troughs, tanks and other vessels.

"Octopus" shows use of magnetic nickel alloy for diverse application

THIS MAN HOLDS a deceptively simple Eriez tool, well-named a magnetic "Octopus."

It is completely non-electric. Yet its powerful, permanent magnetic strength is capable of lifting and holding ferrous metal objects or masses weighing 75 to 100 pounds.

This potent, permanently dependable magnetic power stems from ALNICO . . . an aluminum-nickel-cobalt-iron alloy.

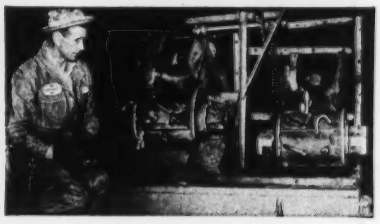
The remarkable permanent magnetic strength of this nickel alloy provides two basic advantages:

(1) No need for electromagnets, current and accessory equipment.

(2) Reduction of tool size and weight to desirable limits.

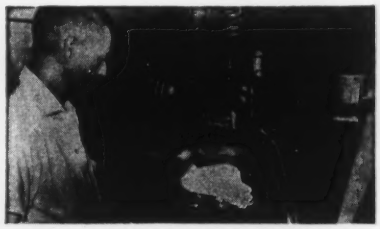
These are utilized in tools made by Eriez Manufacturing Company, Erie, Pa. for hundreds of diverse applications.

The addition of nickel... essential in Alnico permanent magnets . . . helps scores of other alloys meet particular fabrication and service demands. So if you encounter difficulty with metal for a specific application, let us give you some practical help. Write for . . . List A of available publications. A simple form makes it easy for you to outline your problem.



Better Product Assured where Eriez permanent magnetic drums remove stray iron from tallow and meat scraps.

Safeguards Hammer Mill. Eriez non-electric magnetic pulley removes tramp iron from wood chips on belt feeding the mill and explosive mixtures beyond.



Cleans Powdered Chemicals. Eriez permanent magnetic grate removes invisible iron particles from drugs and the like.

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

—ITEM 193—

For More Information Circle Item Number on Yellow Card—page 19

In over 100 places, Enjay Butyl rubber parts

add to Pontiac performance

Axle bumper

Body seals, gaskets, insulators, pads, grommets, etc.

Brake and accelerator pedal pads, bellows

Radiator and heater hoses, ducts

Gearshift lever cover

Pontiac has been using parts made of Enjay Butyl since 1946. The great '56 model now incorporates more than 100 parts made from this super-durable rubber, adding to its performance, style and value. These parts have amazing resistance to deterioration and will easily last the life of the car.

Among the many advantages of Enjay Butyl are *price* and *ready availability*. And it is now available in non-staining grades for white and light-colored parts. Extensive laboratory and testing facilities are at your service. For the full story, contact the Enjay Company today.

ENJAY BUTYL

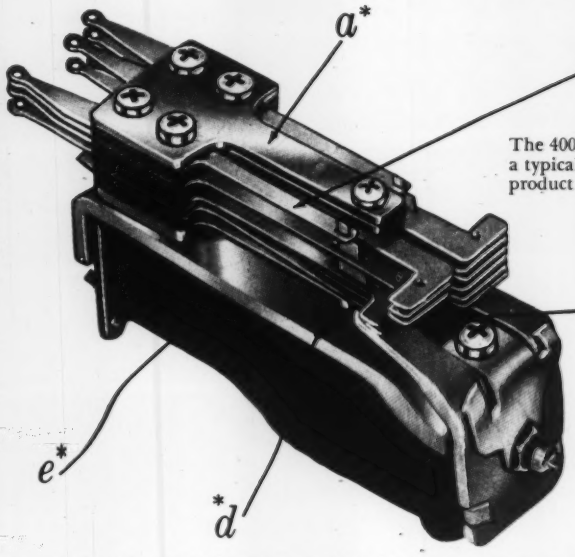
Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture

ENJAY **ENJAY COMPANY, INC.,** 15 West 51st Street, New York 19, N. Y.
District Office: 11 South Portage Path, Akron 3, Ohio

36 SUCCESSFUL YEARS OF LEADERSHIP IN SERVING INDUSTRY

Want true ratings on your relays?

We have had 58 years to get acquainted with these relays...



The 4000 Type Relay a typical Kellogg product for industry.

Making and improving these relays during the past 58 years has taught us to know them very well. The use of these relays in our own equipment has helped to make Kellogg the leader in the independent telephone field.

You can save design time and cut production costs because our intimate experience as a relay-user as well as relay-maker enables us to develop relays that are rated to meet your requirements... to build them to stand up in your equipment, for a lifetime of service... to stock them for early delivery.

For instance, we have in stock thousands of variations on the standard Kellogg 4000 Type Relay, including time-delay, twin, snap-action, multi-contact, and plug-in relays. You can anticipate their performance in any application because we have *true* ratings on every one of them.

*

For the A.B.C.'s of the 4000 type relay and other Kellogg relays use the coupon to send for this Kellogg Relay Bulletin.

KELLOGG SWITCHBOARD AND SUPPLY COMPANY
A Division of International Telephone and Telegraph Corporation
Sales Offices: 79 W. Monroe St., Chicago 3, Ill.

Industrial Sales Dept.

☐ Please send me the booklet on Kellogg Relays

NAME_____

FIRM_____

STREET_____

CITY_____ ZONE____ STATE_____

KELLOGG
KELLOGG A DIVISION OF IT&T

KELLOGG SWITCHBOARD AND SUPPLY COMPANY
A Division of International Telephone and Telegraph Corporation
Sales Offices: 79 W. Monroe St., Chicago 3, Ill.

QUALITY COMPONENTS FOR INDUSTRIAL CONTROL
QUALITY COMMUNICATIONS SYSTEMS

Kellogg Branch Warehouses and Offices

6000 W. 51st Street
Chicago 38, Illinois
REliance 5-5445

4501 Truman Road
Kansas City 1, Missouri
Humboldt 7085

410 N. Syndicate Avenue
St. Paul 4, Minnesota
Nestor 5878

KELLOGG Branch Office:
406 S. Main Street
Los Angeles 13, Calif.
Vandyke 6759

1515 Turtle Creek Blvd.
Dallas 2, Texas
Prospect 5191

1663 Mission Street
San Francisco 3, California
Market 1-6011

1555 West Fourth Street
Mansfield, Ohio
Mansfield 7-2816

Export Distributor:
International Standard Electric Corp.
50 Church Street
New York 7, New York

45 years OF SERVICE TO INDUSTRY

They asked for the "impossible" . . . and got it!

Here's the die casting that "couldn't be made." But Stewart found a way to turn out 12,000 a week.

This helical gear is only one example of how many firms large and small have put Stewart's long experience to work.

Perhaps *you* have need for a die casting. Whatever it is, you can count on Stewart to meet your specifications . . . accurately, and *on time.*

This emblem is your assurance that the zinc alloy used in every Stewart die casting meets the rigid specifications established by the American Die Casting Institute.

Stewart DIE CASTING

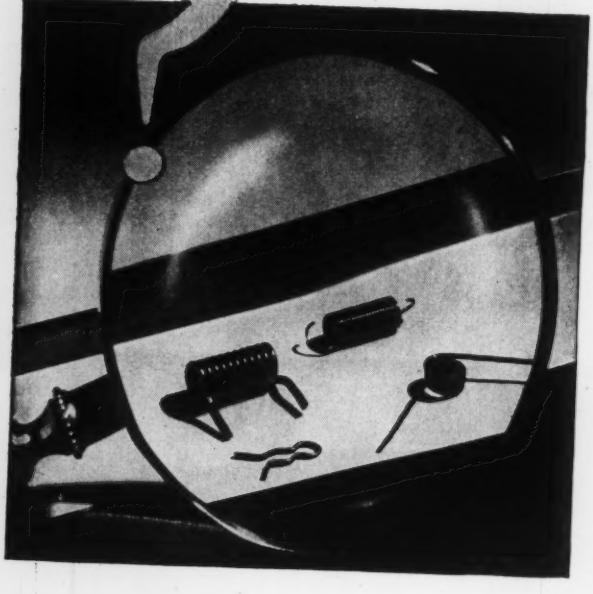
A DIVISION OF
STEWART-WARNER CORPORATION

Chicago, Illinois: 4535 Fullerton Avenue
Bridgeport, Connecticut: 273 Warren Street

STEWART SW WARNER

BIG springs?

-little springs



-simple springs

Get custom-made performance and volume prices with American Quality Springs

-tricky springs?

SOME OF OUR BEST CUSTOMERS still find it hard to believe that American Steel & Wire can turn out such an incredible variety of springs: we make extension springs, compression springs, torsion springs, motor springs, flat spiral springs, flat springs, and wire forms with an endless variety of end formations. Cold wound and heat treated.

Materials? Carbon steel wire, hard drawn, oil tempered and annealed, music wire, chrome-vanadium wire, Stainless Steel, monel, phosphor bronze, brass or just about any other spring metal you can name.

Finishes? Springs can be supplied ground, polished, shot blasted, ball blasted; coated with japan, lacquer, zinc, cadmium, copper, nickel or just about any other material that can possibly be applied.

American Steel & Wire can supply completely fabricated spring assemblies, too. A complete assembly department can produce, *at low cost*, such items as parking brake assemblies.

Take advantage of our complete spring engineering design service, this great range of varieties; get rapid delivery and low prices—with American Quality Springs. Just call your nearest AS&W salesman.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

USS AMERICAN QUALITY SPRINGS

UNITED STATES STEEL

Selling Points Galore!

and the *telling touch* is

MADISON-KIPP

zinc and aluminum die castings

To finalize the sale of competitive "counter goods" quickly requires pre-planning and good judgment on the part of the product designer.

The skilled and experienced craftsmen at Madison-Kipp can often assist in providing the "telling touch" that might otherwise be missed.

Please clip this ad as a reminder to contact us when you have die casting requirements.

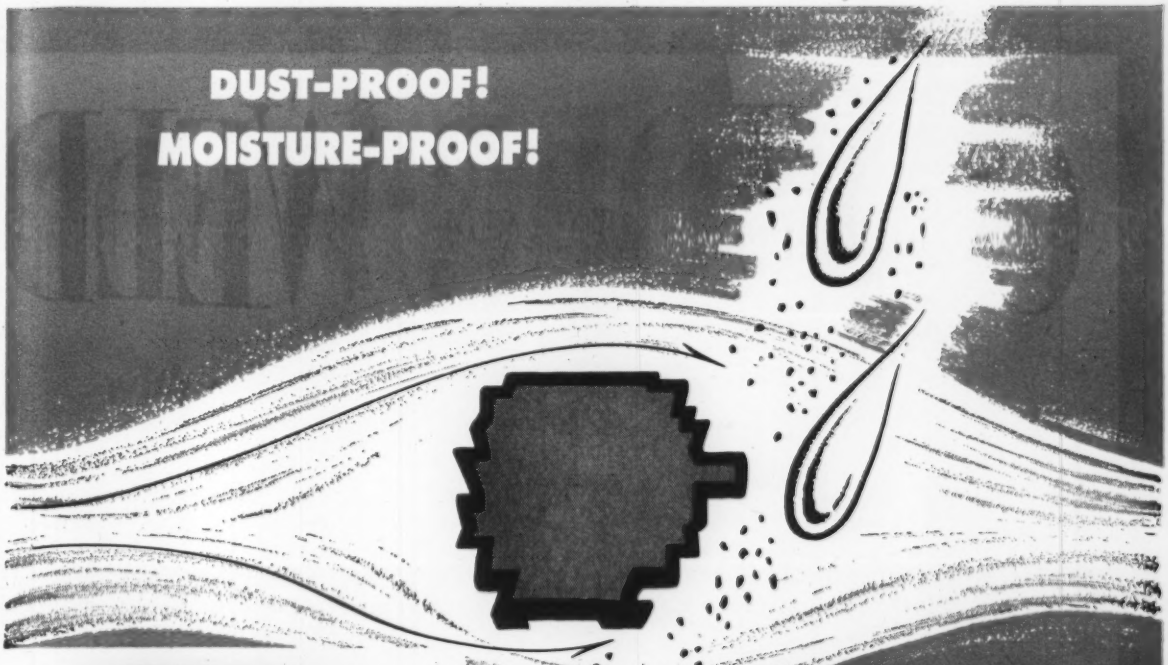
kipp

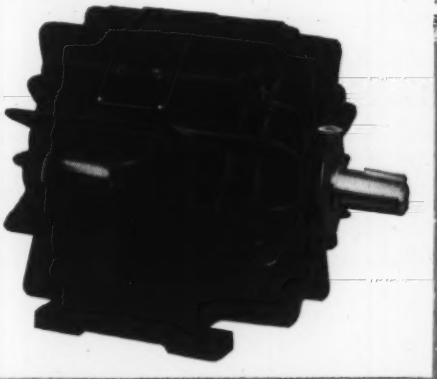
MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U. S. A.

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

—ITEM 198—
For More Information Circle Item Number on Yellow Card—page 19

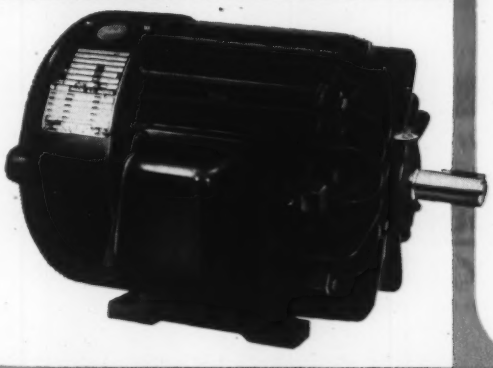
DUST-PROOF!
MOISTURE-PROOF!





TWO NEW
"DIEHL MOTORS FOR
Air-Over-Motor"
APPLICATIONS

Type "DIE" Motor (Not Fan-Cooled)



Type "DIF" Motor (Fan-Cooled)

Tops in Quality — Competitive in price!

When you buy or specify motors for fans, blowers, unit heaters, air conditioners, cooling towers or dehumidifying systems *don't overlook* these two new standard or custom-designed Diehl Totally-Enclosed Motors.

Smaller in size, lighter in weight, precision-engineered and precision-built to new **NEMA** standards, they are ideally suited to "air-over-motor" applications where moisture, fumes, dust and other airborne particles are a problem ... a field in which Diehl has long been a leader.

Diehl

Tops in Quality—
Competitive in price!

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

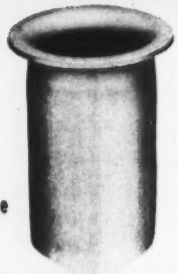
Please send me the following bulletins:

☐ New Type "D" Motor Bulletin No. **MD-3304**
☐ Consolidated Catalog & Price List No. **MD-3310**

Name_____
Company_____
Street_____
City_____ State_____

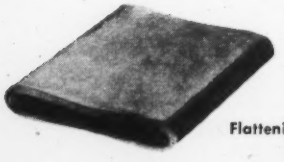
INTEGRAL AND FRACTIONAL HORSEPOWER MOTORS ARE AVAILABLE IN A WIDE RANGE OF TYPES AND SIZES

—ITEM 199—
For More Information Circle Item Number on Yellow Card—page 19



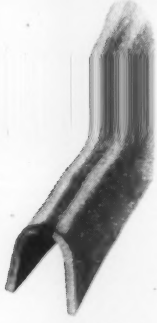
Flare and Flange

Pressure (Tubing)

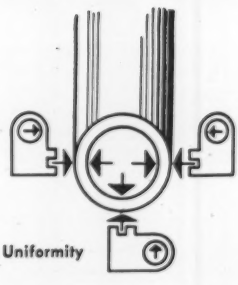


Flattening

CONTOUR-WELD PIPE...BEST BY ANY TEST YOU CAN NAME



Reverse Bend (2⅜" O.D. x .154 Wall)



Uniformity

new stainless pipe

with a weld so smooth you can't even feel it

Run your finger over the weld area inside Trent's new *Contour-Welded** pipe. We doubt if you can even feel the weld. It's that smooth! There's no weld bead . . . no undercut . . . no place for corrosion or erosion to get a start.

Here's the reason: *Contour-Welding* is an entirely different method of producing welded pipe and tubing. It puts gravity to work to pull down the molten weld-metal to conform with the exact contour of the pipe. That means a smooth, clean weld practically indistinguishable from the pipe itself.

Contour-Weld Means Trent's Better Than Ever

As always, this new TRENTWELD pipe and tubing is made from uniformly rolled stainless strip. Wall thickness is always the same throughout the pipe . . . and *Contour-Welding* brings this same high uniformity to the weld zone itself. All this, plus Trent's superior cold-working methods, gives you a stronger pipe or tube, with smoother flanged or flared ends.

Try new TRENTWELD pipe or tubing on your next job. It's available in any gage, for all applications including high-pressure hydraulic lines . . . high-velocity systems . . . lines carrying corrosive chemicals. And new *Contour-Welded* tubing is available in most grades, including Hastelloy, Zirconium, Zircoloy, Titanium and 19-9-DL. You'll find that TRENTWELD can't be beat by any other pipe – welded or not.

*Contour-Weld is the trade mark of the Trent Tube Company for its process of welding pipe and tubing which is protected under U.S. Patent 2,716,692.

Why Trent's Exclusive Contour-Weld Process Means Smoother Welds . . .

Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the I.D. surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.

But Trent put a stop to that – simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom – and gravity works for them. For then, the bulge is in the opposite direction – blending in perfectly with the contour of the pipe itself.

TRENTWELD **STAINLESS STEEL TUBING**

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

—ITEM 200—

$\frac{T^P + F}{H^e} = YS$

use the SYNCHRON* formula to solve your timing problem

The Synchron Formula can help you cut production costs, make designs *work* the way you plan them.

Apply it to your timing problem. Gather the factors . . . T^P, the *Timing Problem*, plus F, the *Facts* (proposed mounting methods and a simple sketch). Send this data to the denominator in our equation . . . H^e, the *Hansen Engineering Department.*

$T^P + F$ divided by H^e equals YS, *Your Solution* to the problem and an answer that will help your design to be more sound, still less expensive to produce.

You'll find the Synchron Formula an easy way to the solution of your timing motor problem. Hansen Engineers are specialists; learn to rely on their 48 yrs. of experience designing, building, testing, and specifying timing motors for every type of application.

Scores of manufacturers look to Synchron Motors and Hansen Engineers to match the timing specs in the development of their designs. This trust is priceless to both Hansen and its customers . . . a pledge of confidence as famous as the Synchron Motor.

Take advantage of the Synchron Formula, by contacting your Synchron Representative, or write direct to Hansen. Your inquiry will be given prompt, confidential attention.

h "Workhorse of the industry

*SYNCHRON synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140° F.; start instantly under load; pull up to 30 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

SYNCHRON

SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNA-TORC D.C. MOTORS

HANSEN MANUFACTURING CO., INC. ESTABLISHED 1907 PRINCETON 12, INDIANA

FACTORY REPRESENTATIVES: *The Fromm Co., 5254 W. Madison St., Chicago, Ill. • R. H. Winslow • Assoc. 123 E. 37th St., New York, N. Y. • Electric Motor Engineering, Inc., 8255 Beverly Blvd., Los Angeles, Cal. • Lawrence Sales Co., Box 13026, Dallas, Texas*

—ITEM 201—

For More Information Circle Item Number on Yellow Card—page 19

Steel-Weld FABRICATION

Use WELDED STEEL for Greater Strength with Less Weight!

Illustrated above is one of two Walking Shoes for a large wheel excavator employed in strip mining operations . . . it is one of many heavy parts and assemblies of parts fabricated and machined by Mahon for manufacturers of several types of mammoth earth moving machines. If you can use weldments to advantage in your product, you can turn to Mahon for complete service including design or redesign, fabrication, machining and assembling. Steel-Weld Fabricated parts and products shown at left are typical of thousands produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you need weldments, or welded steel in any form, you will find a unique source in the Mahon organization . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures a smoother, finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or write for Booklet showing Mahon's facilities to serve you.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

—ITEM 202—

For More Information Circle Item Number on Yellow Card—page 19

Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

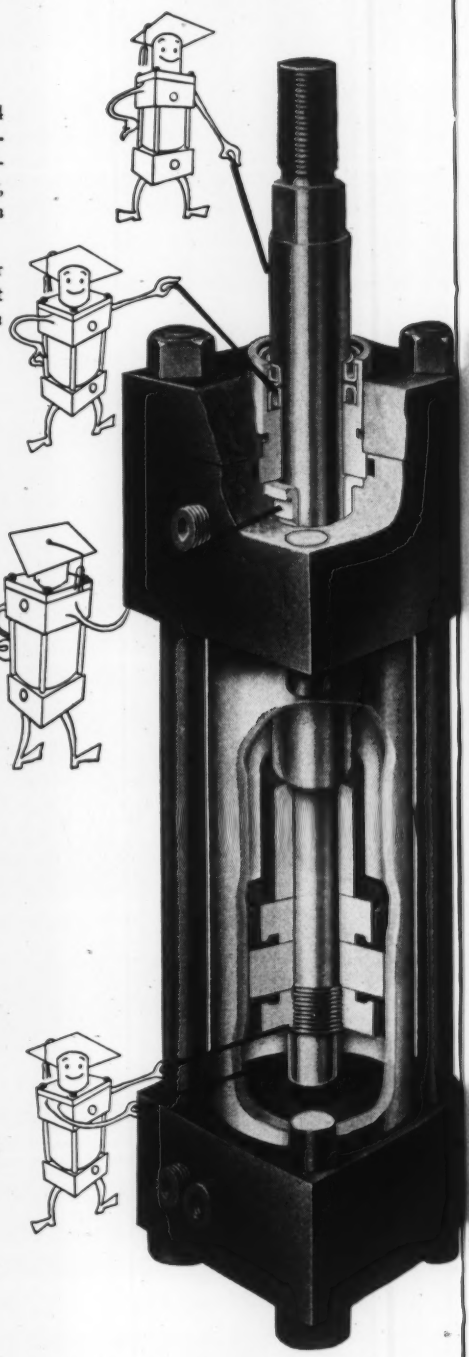
(Standard on Miller Cylinders at no extra cost)

Specify CASE-HARDENED CHROME PLATED PISTON RODS On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***



Specify "TEFLON" WIPERS On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

Specify TEFLON HYDRAULIC ROD SEALS On all Hydraulic Cylinders

Specify BLACK FERRIC OXIDE SURFACES On all Air and Hydraulic Cylinders

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)

You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

See These New Features on Miller Cylinders at Miller

BOOTH No. 429

A. S. T. E. SHOW, March 19-23

International Amphitheatre, Chicago

MILLER FLUID POWER CO.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
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FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE
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TORONTO, CANADA and OTHER AREAS

Miller

In 1945-46 You Benefited . . .

From the following quality cylinder "Firsts" offered by Miller Fluid Power Company on its standard catalogued power cylinders:

1. Square bar steel heads, caps, and components
2. Welded fabricated steel mountings
3. Detachable, interchangeable steel mountings
4. High tensile steel tie rods (4 per cylinder)
5. High tensile steel piston rods
6. Chrome Plated Piston rods
7. Wrench flats on piston rods
8. Non-corrosive tubing on large bore air cylinders
9. Step-cut piston rings on hydraulic cylinders
10. Dirt wipers on air cylinders
11. Dirt wipers and oil wipers on hydraulic cylinders
12. Non-adjustable, bubble-tight, leakproof piston rod seals on air cylinders
13. Non-adjustable, bubble-tight, leakproof piston seals on air cylinders
14. Non-adjustable, leakproof, hydraulic piston rod seals guaranteed not to leak even one drop of oil
15. Non-adjustable, leakproof, hydraulic piston seals guaranteed not to leak even one drop of oil
16. 98% plus operating efficiency on air cylinders of 4" and larger bores at 80 psi
17. 98% plus operating efficiency on hydraulic cylinders of 4" and larger bores at 130 psi
18. 1 psi no-load break loose pressure on air cylinders of 3¼" bore and larger
19. 3 psi no-load break-loose pressure on hydraulic cylinders of 4" bore and larger
20. Seal life in excess of several hundred million feet of piston rod travel on all of the above-mentioned piston seals
21. Precision-seal cylinders
22. Seals that seal with pressure on all hydraulic static seals
23. Catalogued line of hydraulic cylinders of 2000 to 3000 psi operating pressure

In 1954 You Benefited again —from Miller's . . .

24. Sizable stock cylinder program
25. Model 77 heavy duty detachable foot mountings

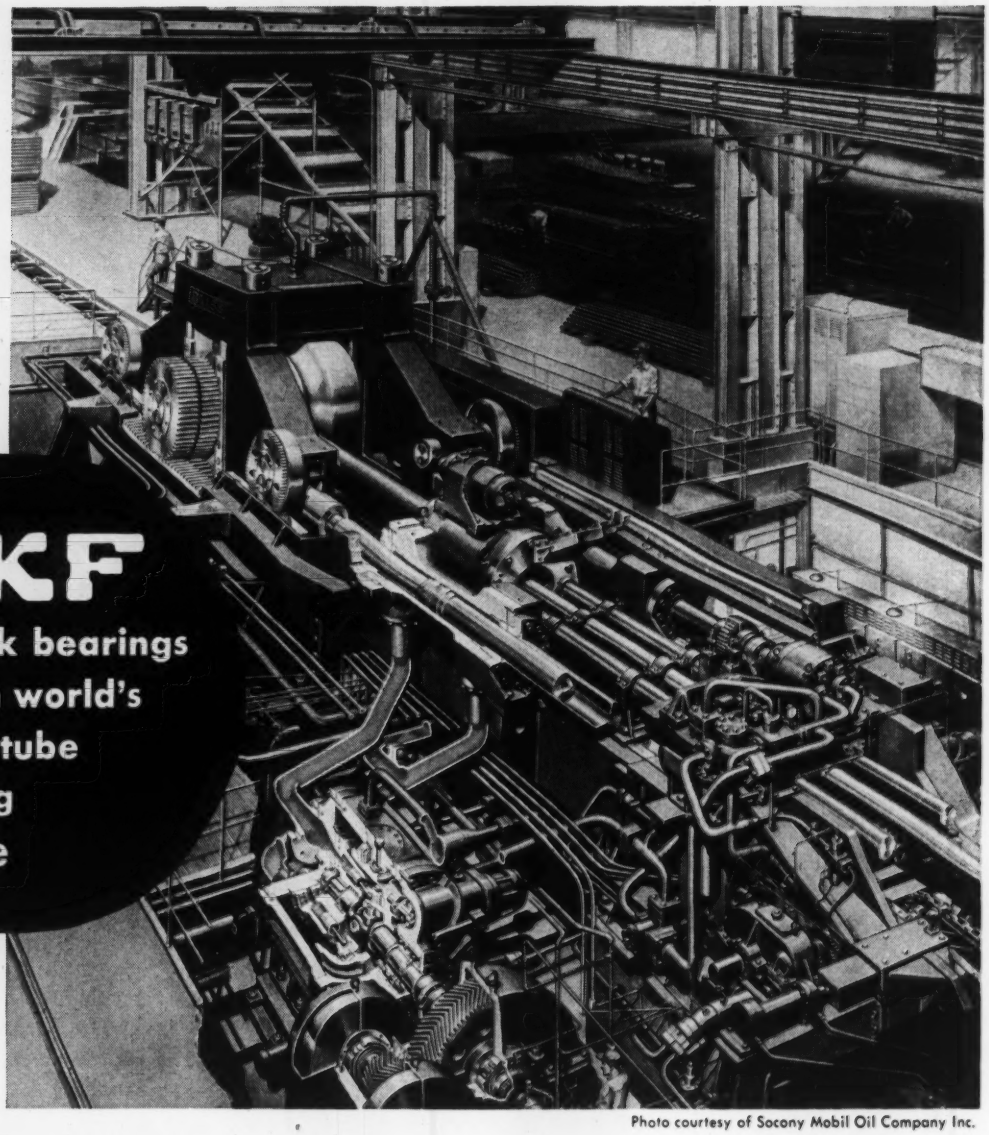
In 1955 You Benefited again —from Miller's . . .

26. Greatly expanded stock cylinder program
27. Case-hardened, chrome plated piston rods
28. "Teflon" hydraulic piston rod seals
29. "Teflon" dirt wipers on air cylinders
30. "Teflon" dirt and oil wipers on hydraulic cylinders
31. High quality rust preventive finish on all parts not otherwise protected from rust on both air and hydraulic cylinders

Enter in boxes above the YEAR in which your supplier first (if at all) gave you these benefits.

In 1956, You Will Benefit Again . . .

Watch For MORE Miller Firsts!



SKF

roll neck bearings used on world's largest tube reducing machine

Photo courtesy of Socony Mobil Oil Company Inc.

SKF sphericals absorb tremendous punishment, provide greater bearing capacity

This 102 foot long giant tube reducing machine, designed and operated by Tube Reducing Corporation, Wallington, N. J., for the U. S. Navy Bureau of Aeronautics, and built by E. W. Bliss Company, Canton, Ohio, puts a 3½ million pound squeeze on precision tubing of outer diameter sizes ranging from 9 to 17 inches for military and commercial cold finished tubular products.

The mammoth bearings for 50" diameter rolls on the machine are SKF Spherical Roller Bearings. They are the largest spherical roller bearings of this type ever made, with a rated capacity of 3,200,000 lbs. Each bearing weighs 5150 lbs.; individual rollers weigh 39½ lbs.

The Tube Reducing Corporation first employed SKF Spherical Roller Bearings in 1937 for a 2¼" tube reducing machine having 13" diameter rolls. Today, *all* tube reducers in this plant are SKF-equipped... from the smallest to the 102 foot giant.

Like the men at Tube Reducing Corporation, organizations that pioneer advancements in their fields are accustomed to find that SKF matches their vision with advanced bearing design that helps them make a working reality of their most ambitious and forward-looking plans.

Make SKF Engineering cooperation a *plus* factor in the successful realization of your company's planning and development program. 7631

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA., *manufacturers of* SKF *and* HESS-BRIGHT® *bearings.*

SKF®

BALL AND ROLLER BEARINGS

—ITEM 204—

For More Information Circle Item Number on Yellow Card—page 19

(Advertisement)

Design data on adhesives

Armstrong

ADHESIVES • COATINGS • SEALERS
USED WHEREVER PERFORMANCE COUNTS

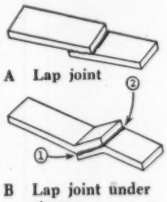
NUMBER ONE

How to design joints for adhesives

Many common joints can be re-designed to give maximum strength with adhesives. The examples shown do not cover every situation, but they do illustrate how four basic design rules can be applied to improve strength. These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which the adhesive is weakest.

Strengthening a lap joint:



Under stress, a common lap joint such as "A" tends to deflect as the assembly aligns itself. Instead of a simple shear stress, the joint in effect more nearly resembles drawing "B". The tension effect at edges "1" and "2" tends to peel the bond apart, since a high proportion of the load is carried at the edges of the lap.

Remedy
Joggle lap (better)

Greater proportion of bonded area now contributes to strength. (Rule 2) Stress is now reduced in the direction in which the adhesive is weakest. (Rule 4)

Beveled lap (better)

Even greater proportion of bonded area now contributes to strength (Rule 2) Stress is further minimized in the direction in which the adhesive is weakest. (Rule 4)

Scarf (best)

Maximum proportion of bonded area now contributes to strength. (Rule 2) Adhesive is now stressed in the direction of its maximum strength. (Rule 3) Stress is now minimized in the direction the adhesive is weakest. (Rule 4)

Production line application of adhesives

It is as important to choose the right method of applying the adhesive as it is to select the proper adhesive.

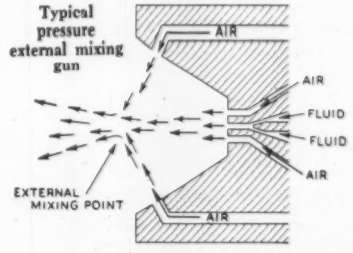
A straight-line manufacturing process with parts handled by a mechanical conveyor obviously is the most desirable setup. The adhesive is applied at the first stage, the adhesive film prepared for bonding in the second stage, and the application of pressure, if necessary, in the third stage.

The methods of application most suitable to straight-line production are spraying and roller coating.

1. Spray coating

Spray coating offers the same advantages for adhesives as for paints. Adhesives ranging from water-thin resins to viscous synthetic rubber products and even abrasive-filled materials are applied in this manner.

Some adhesives and coatings may be applied as an even, perfectly smooth film. Materials of this type should be sprayed with a pressure type (not suction) external mixing gun. The intermediate nozzle or fluid opening sizes ordinarily used for paints will control the amount of fluid ejected into the air stream, so that all of the fluid is "atomized." Fast-drying adhesives, particularly those based on synthetic rubber, cannot be applied with



paint smoothness, but will spray with uniformity in almost any thickness desired. Selection of the correct air gap and fluid opening is important. Large fluid openings are better with viscous adhesives, but only if air pressure can be increased proportionately. With synthetic rubber type adhesives, higher air pressure is usually needed for breakup of the fluid stream.

Adhesives of this type can be improved by lowering the viscosity by dilution, using the recommended solvent. In using an adhesive that has been severely thinned, it must be remembered that solids content is low.

In many applications, the speed and economy offered by automatic spray equipment will quickly repay the investment required. Where the nature of the work requires hand spraying, some of the more important points are: hold the gun no more than 7" or 8" from the work; "trigger" the gun at the end of each pass rather than attempt to operate the gun continuously; hold the gun at right angles to the work to insure uniform film thickness.

2. Roller coating

Where continuous production runs of sheets of one thickness are involved, roller coating is fast and economical.

If properly compounded, most water base adhesives will roller coat on standard equipment.

Fast-drying adhesives of the synthetic rubber type require slight machine modification and a different technique. Most solvents for adhesives will attack rubber or plastics so that metal rolls must be used throughout. Synthetic rubber adhesives tend to adhere to the applicator roll and will not apply uniformly from a smooth-surfaced roll. To remedy this, the roll should contain "reservoirs" for the adhesive and enough surface irregularity to prevent suction. This may take the form of grooves at right angles to the roll axis or small cups engraved on the roll. In either case, the area between the grooves or the cups should be cross-hatched or broken up in some way. The amount of adhesive applied is determined by the depth of the machined "reservoirs" and their spacing.

While the coater is in use, the adhesive should be prevented from losing solvent by evaporation, which increases viscosity. To do this, the adhesive should be fed to the pan continuously at the used rate. The pan should be covered or the adhesive stirred in the pan for uniform feed to the take-up roll. Production should be as nearly continuous as possible.

For more information on adhesives—and design problems involving adhesives—write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, Industrial Div., 8002 Dean Street, Lancaster, Pa.

DESIGN SOLUTIONS with G-E

G.E. OFFERS SPECIAL SOLUTIONS FOR YOUR SPECIAL ELECTRIC-DRIVE PROBLEMS

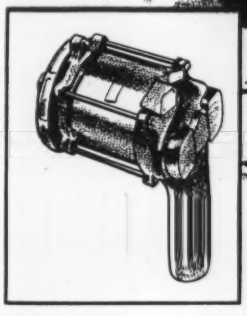
DID YOU KNOW GENERAL ELECTRIC'S SPECIALTY COMPONENT MOTOR DEPARTMENT DESIGNS AND BUILDS THOUSANDS OF SPECIAL MOTORS AND GENERATORS TO SOLVE SPECIAL ELECTRIC-DRIVE PROBLEMS ON YOUR PRODUCTS? THIS DEPARTMENT'S COMPLETE SPECIALTY-MOTOR LINE INCLUDES A WIDE VARIETY OF SMALL AC AND DC MOTORS AND GENERATORS, ALTERNATORS, AMPLIDYNES, TACH GENERATORS, DYNAMOTORS, AND UNIVERSAL MOTORS. AND THE G-E MOTOR ENGINEERS READY TO WORK WITH YOU WILL EXPERTLY MODIFY BASIC DESIGNS TO PROVIDE THE CHARACTERISTICS, ENCLOSURE, SIZE AND SHAPE, AND SPECIAL ACCESSORIES **YOU** REQUIRE FOR **YOUR PRODUCTS.**

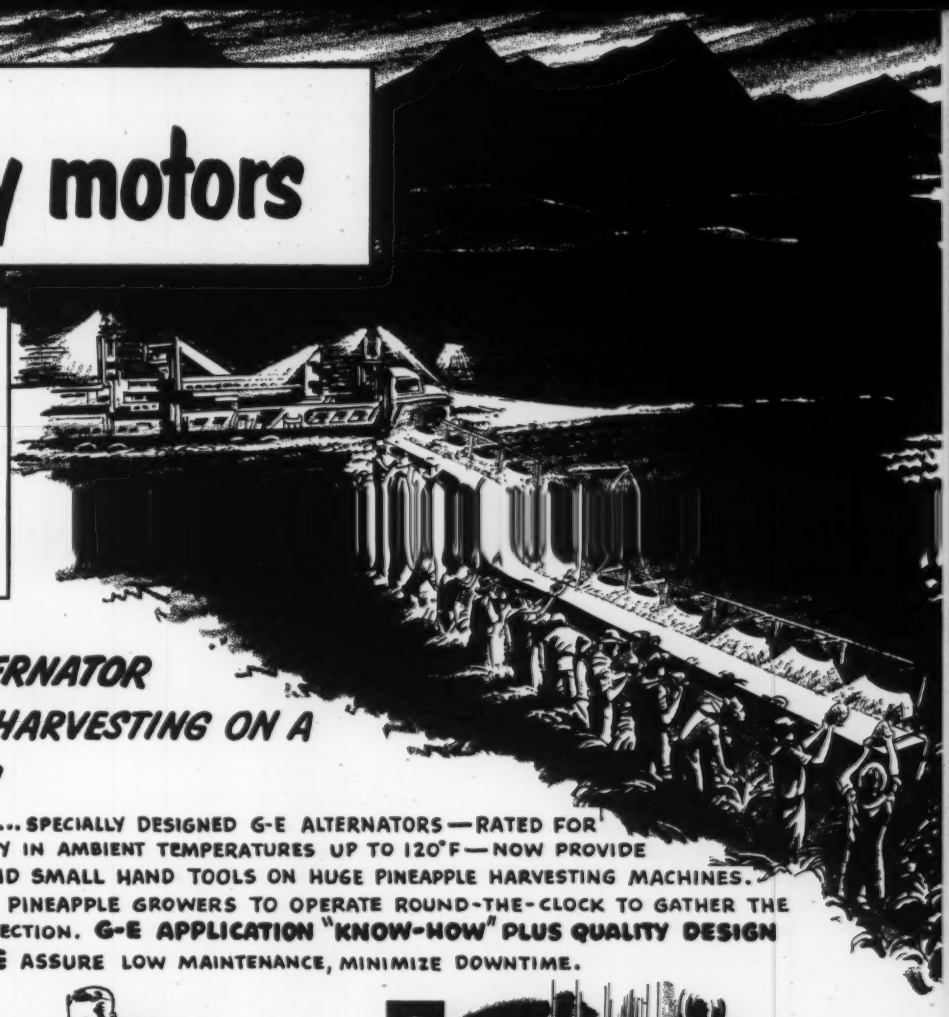
WHERE CAN YOU USE THIS NEW, GEARLESS LOW-SPEED AC MOTOR?

ONLY G.E. OFFERS THIS SYNCHRONOUS INDUCTOR MOTOR—OPERATING AT LOW SPEED ON 115 OR 230-VOLT AC POWER. LIMITLESS USES INCLUDE MOTOR-OPERATED VALVES, MACHINE TOOLS, REMOTE-CONTROL SYSTEMS. RAPID ACCELERATION, DECELERATION, REVERSING. SEALED-IN LUBRICATION FOR LONG LIFE.

TWO MODELS: 75 RPM, 75 OZ-IN.; 100 RPM, 2 OZ-IN.

specialty motors





SPECIAL G-E ALTERNATOR PUTS PINEAPPLE HARVESTING ON A 24-HOUR BASIS

... SPECIALLY DESIGNED G-E ALTERNATORS—RATED FOR CONTINUOUS DUTY IN AMBIENT TEMPERATURES UP TO 120°F—NOW PROVIDE POWER FOR FLOODLIGHTS AND SMALL HAND TOOLS ON HUGE PINEAPPLE HARVESTING MACHINES. THIS PERMITS HAWAII'S PINEAPPLE GROWERS TO OPERATE ROUND-THE-CLOCK TO GATHER THE FRUIT AT THE PEAK OF PERFECTION. **G-E APPLICATION "KNOW-HOW" PLUS QUALITY DESIGN AND MANUFACTURE** ASSURE LOW MAINTENANCE, MINIMIZE DOWNTIME.

AVAILABLE: COMPLETE ENGINEERING ASSISTANCE FOR YOU!

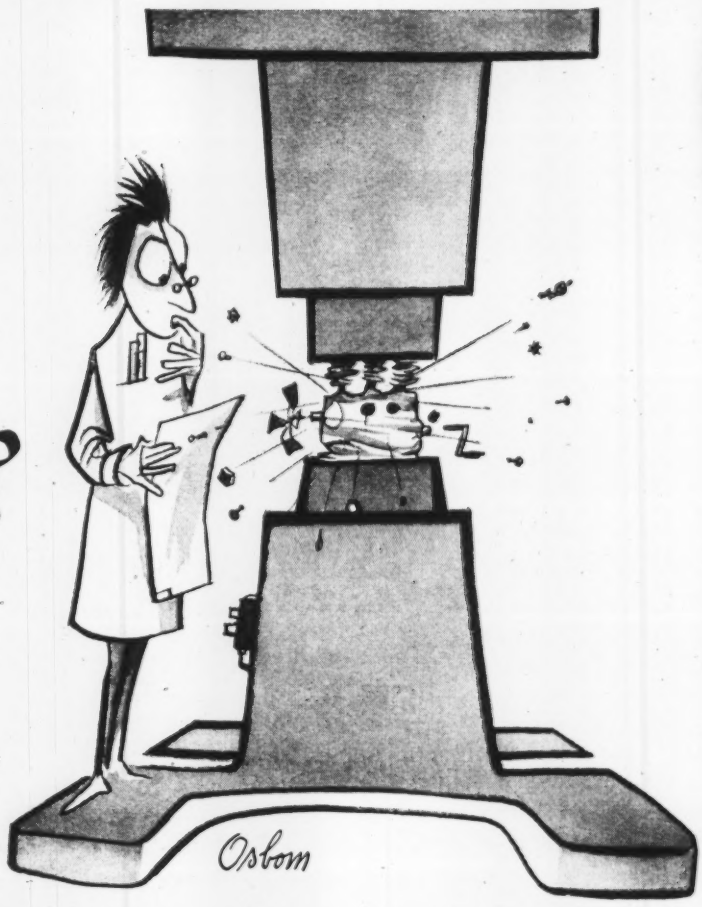
HERE'S THE SPECIAL ATTENTION YOUR PROBLEMS GET AT G.E.:
1. YOUR LOCAL G-E APPARATUS SALES ENGINEER LEARNS ALL ABOUT YOUR NEEDS FROM YOUR DESIGN PEOPLE.
2. HE CALLS IN A TEAM OF FACTORY ENGINEERS WITH YEARS OF MOTOR APPLICATION EXPERIENCE. 3. AT THEIR DISPOSAL ARE G.E.'S COMPLETE DEVELOPMENT AND TESTING FACILITIES. 4. IN SHORT ORDER, A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCT.

FOR THIS COMPLETE HELP, CONTACT YOUR NEARBY G-E APPARATUS SALES OFFICE, TODAY. OR IF YOU PREFER, **WRITE** GIVING FULL DETAILS TO SECT. 704-58, GENERAL ELECTRIC CO., SCHENECTADY 5, N.Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Trying to make it SMALLER?



Faced with "impossible" problems in the increasingly critical field of design diminution, weight and size reduction, power and component capsulation?

O.K. Consider coupon! Why not rip out and receive complete story on how MPB* 's such as these

BALL BEARINGS ACTUAL SIZE

are helping to make things smaller and smaller and smaller.

Be smart, clip coupon NOW!

MINIATURE PRECISION BEARINGS, INC., 3 PRECISION PARK, KEENE, N. H.

Send me without charge or obligation
( ) My copy of new MPB Catalog,
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( ) special data on use
of MPB's in the field of _____

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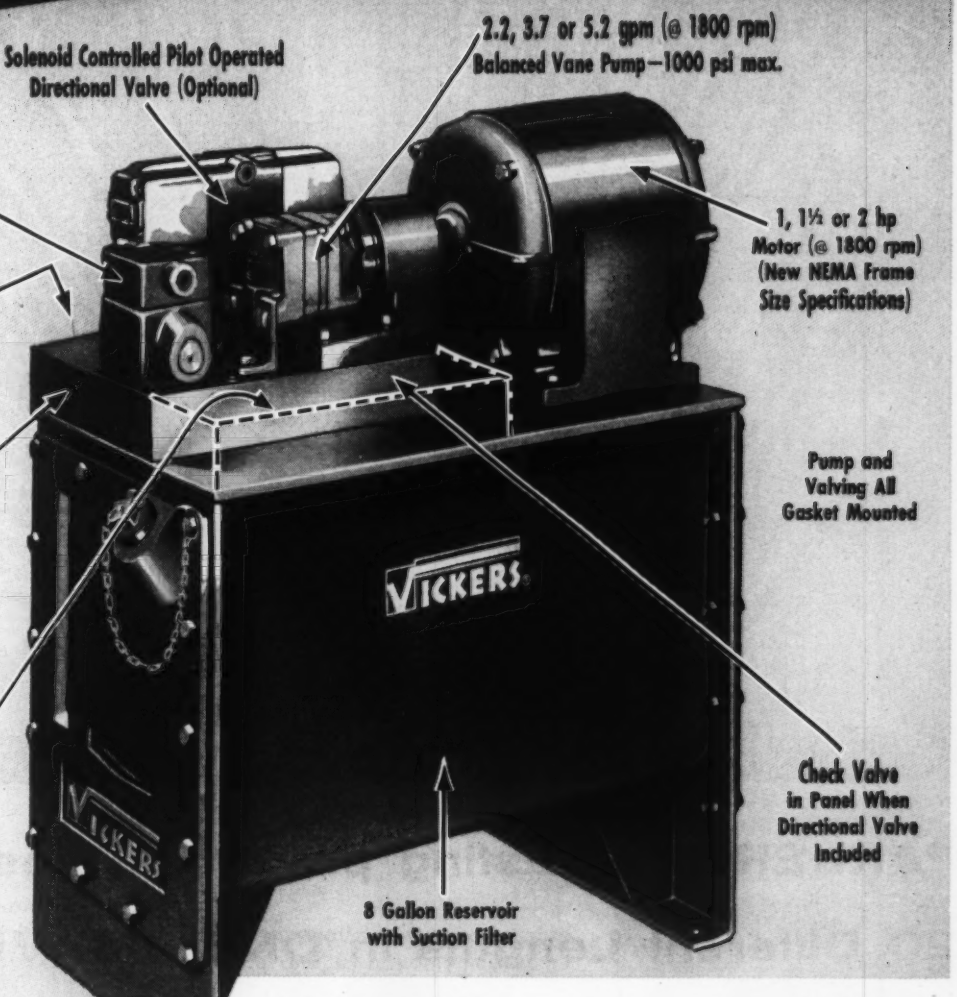
* MINIATURE PRECISION BEARINGS, INC., KEENE, N. H.

—ITEM 207—

For More Information Circle Item Number on Yellow Card—page 19

A NEW IDEA . . . in hydraulic power and control systems


Solenoid Controlled Pilot Operated Directional Valve (Optional)
2.2, 3.7 or 5.2 gpm (@ 1800 rpm) Balanced Vane Pump—1000 psi max.
Balanced Piston Relief Valve
1, 1½ or 2 hp Motor (@ 1800 rpm) (New NEMA Frame Size Specifications)
Pressure and Return Line Connections on Back of Panel
Pump and Valving All Gasket Mounted
Panel Contains Oil Passages Between Pump and Valving So that All External Piping is Eliminated
VICKERS
Check Valve in Panel When Directional Valve Included
A Second Solenoid Controlled Pilot Operated Directional Valve Can Be Provided Here For Control of Additional Operations
8 Gallon Reservoir with Suction Filter

Here is a new and extremely compact "package system" for providing hydraulic power and control to a wide variety of industrial machinery applications requiring low hydraulic horsepower. These include clamping, gaging, transferring, rollover, elevating, indexing, chuck and clutch operations, etc.

Note the many features indicated on the photograph above. The result is improved and simplified hydraulic design . . . also reduced installation and maintenance costs. This "package system" has great flexibility . . . is available in a wide variety of combinations of standard components assembled to suit individual requirements. Pretested and ready for immediate operation, it has also the advantage of undivided Vickers responsibility. For further information, ask for installation drawings 178706-8.

VICKERS Series T8 HYDRAULIC PIPELESS POWER PACKAGE*

7311

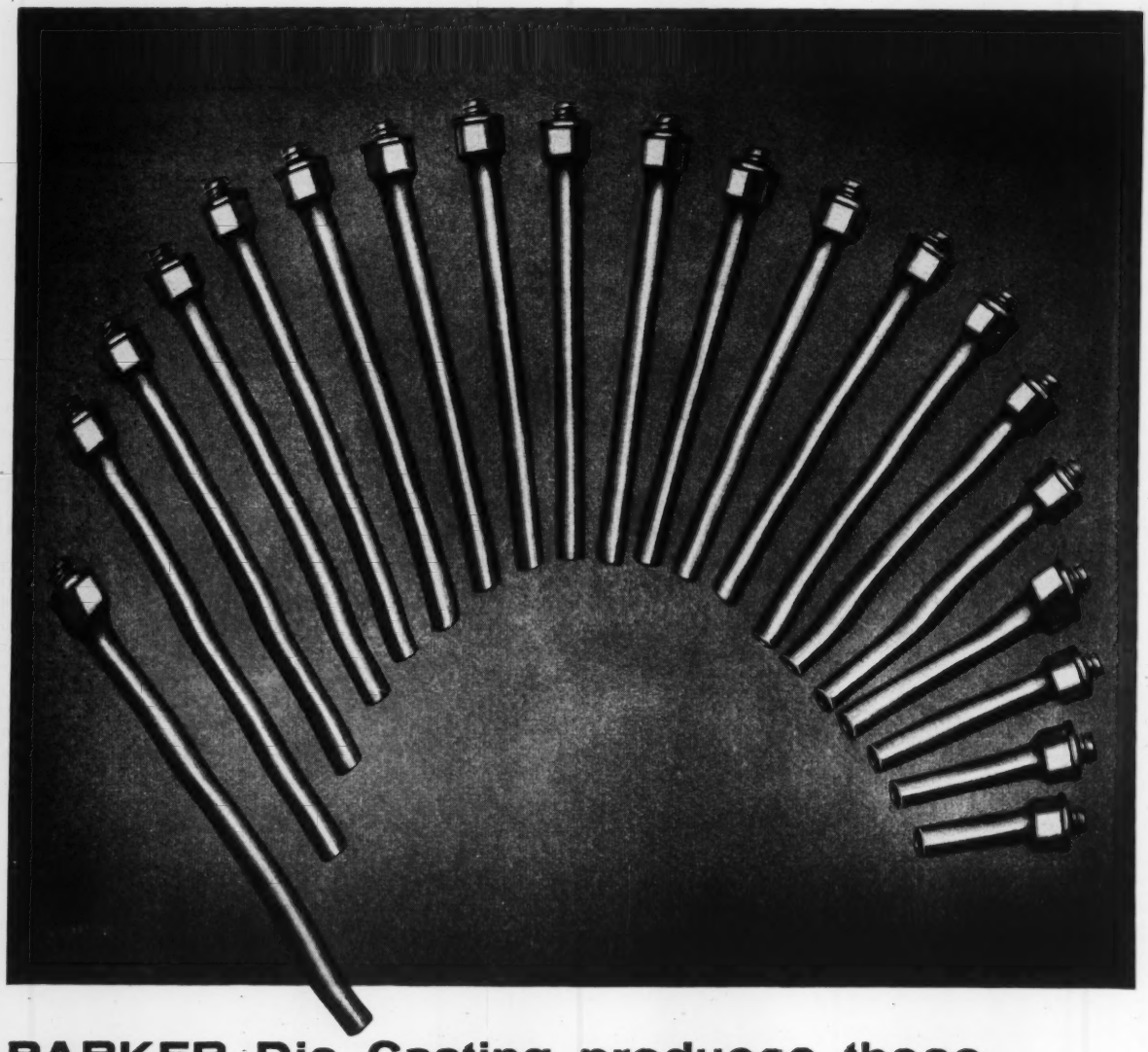
VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
1430 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA WASHINGTON • WORCESTER

IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

*These "package systems" supplement the Vickers line of standard hydraulic power units.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



PARKER Die Casting produces these 20 Different Lengths In ONE 4-CAVITY DIE

PARKER
SALES ENGINEERS

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

CINCINNATI, Ohio
William H. Broxterman • 2174 Buck Street

DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street

KIRKWOOD 22, Mo.
Edward F. Higgins, Jr. • 102 West Adams Street

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

Lower-cost die castings are the result of the die designer's skill, experience and creative imagination. The die castings shown above are a good example. This part was required in 20 different lengths, each threaded on one end and countersunk on the other. The cost of producing multiple cavity dies for these 20 pieces would have been prohibitive. Parker solved the problem by designing one four-cavity die with removable cores of varying lengths. Just think of the savings!

This creative skill in die design is just another example of Parker's most important product: Proving That Die Casting Cuts Component Parts Costs.

In like manner, Parker may be able to save you money on your parts. Just call the nearest Parker sales engineer listed here or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings

POWDERED METAL PARTS

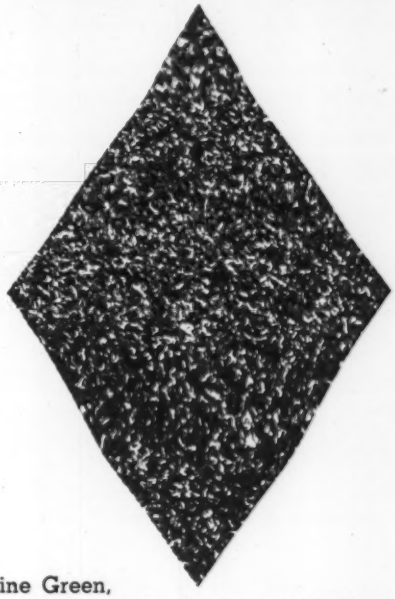
—ITEM 209—

THE MOST AMAZING FINISH DEVELOPMENT IN 100 YEARS!

M & W. CO. SINCE 18[illegible]

COLOR-FLECKED PLEXTONE®

Imagine — a textured *and MULTICOLORED* finish — sprayed at *one* time, from *one* gun, in *one* coat that covers surface flaws and blemishes completely!



PLEXTONE Alpine Green, one of many standard pre-mixed colors available for prompt shipment. Also available in solid colors and in custom multicolors.

CAPSULE FACTS

WHAT IS COLOR-FLECKED PLEXTONE?

A completely new multicolored industrial finish in which colors exist separately. When sprayed, they form an interlacing color network of amazing beauty and durability.

CHARACTERISTICS

Lacquer base • Air dries approx. 30 minutes — dries hard 2 to 3 hours • Available in flat or semi-gloss • Exceptional hiding power — hides surface imperfections, covers porous materials • Remarkable abrasion resistance • Good chemical resistance • Does not stain • Can be scrubbed, even scoured • Quick and easy touch-up, without showing • Available in non-toxic grades • Bonds readily to primed wood, metals such as cast iron, steel, aluminum, brass, copper, zinc; also plastics, woven fabrics, wallboard, paper, cement, plaster, papier-mache forms.

USES

Manufacturers from coast to coast are using PLEXTONE to finish such products as Caskets • Displays • Furniture • Kitchen cabinets • Machinery • Office panels and partitions • Sewing machine tables • Silver chests • Signs • Store fixtures • Switch gear housings • Table lamps and shades • Toys • TV cabinets • Wallboard

PLEXTONE — CUTS FINISHING COSTS UP TO 35%

PLEXTONE often eliminates many pre-finishing steps on wood or metals. Usually no more than one coat of primer and one PLEXTONE coat are required! And PLEXTONE's texture hides wood knots, metal weld marks, flaws and blemishes.

PLEXTONE — AN UNBELIEVABLY RUGGED FINISH

PLEXTONE's color flecks go "through-the-film"! Resists chipping, cracking and abrasion . . . defies alcohol, grease, and oil! So tough, it can be washed, scrubbed, even scoured with abrasive cleansers without surface damage!

PLEXTONE — DRAMATIC SALES APPEAL OF *MULTICOLOR!*

Color-flecked PLEXTONE offers endless new effects . . . from subtle tones-on-tone to brilliant spatter-dash . . . two, three or more colors sprayed from one gun at one time! New sales appeal for any and all products.

PROVE IT TO YOURSELF—

Mail Coupon Today—Send for FREE color chips. See some of the many color combinations possible. Mail coupon NOW for FREE color chips, PLEXTONE sample and complete application data.

MAAS & WALDSTEIN CO.

2134 McCARTER HIGHWAY, NEWARK 4, NEW JERSEY

Midwest Division: 1658 Carroll Ave., Chicago 12, Ill.

Pacific Coast Division:
Smith-Davis Company, 10751 Venice Blvd., Los Angeles 34

PIONEERS IN PROTECTION • OUR 80th YEAR

PLEXTONE®

MAAS AND WALDSTEIN CO., PLEXTONE DIVISION
2134 McCarter Highway, Newark 4, New Jersey

Gentlemen: Please send me FREE color chips, PLEXTONE sample, and application data.
I am particularly interested in PLEXTONE for finishing_____

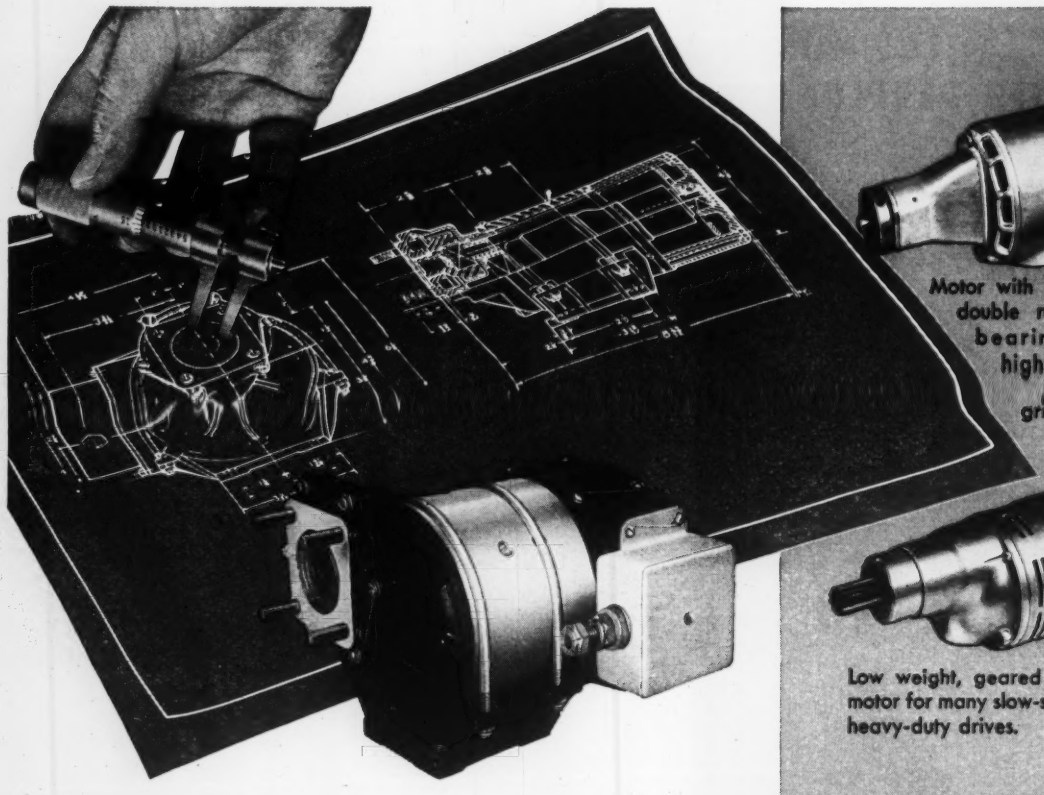
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

—ITEM 210—



a motor designed to your exact product requirements

Many manufacturers of motor-driven products have found that the use of a Lamb Electric *special application* motor results in better products and lower costs.

Our high degree of specialization in both equipment and methods provides the advantages of custom manufacture on a volume basis. High quality and controlled costs go hand-in-hand.

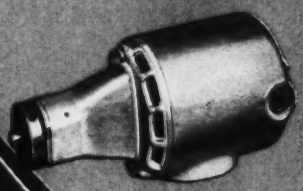
We shall welcome the opportunity to demonstrate the benefits of a Lamb Electric special application motor for *your* products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

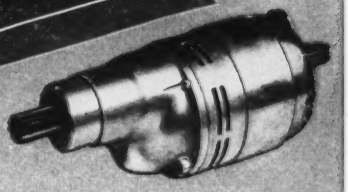
In Canada: Lamb Electric —
Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric

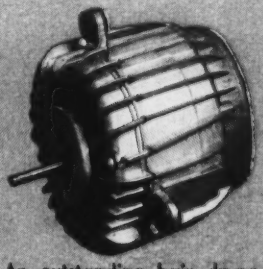
SPECIAL APPLICATION
FRACTIONAL HORSEPOWER **MOTORS**



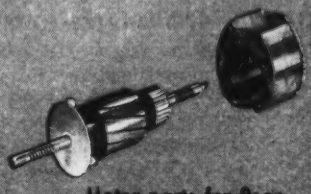
Motor with shaft on double row ball bearings for high speed grinder.



Low weight, geared head motor for many slow-speed, heavy-duty drives.



An outstanding hair dryer motor. Design insures quiet, vibrationless operation.



Motor parts for floor polisher. Adaptable to food mixers and other home appliances.

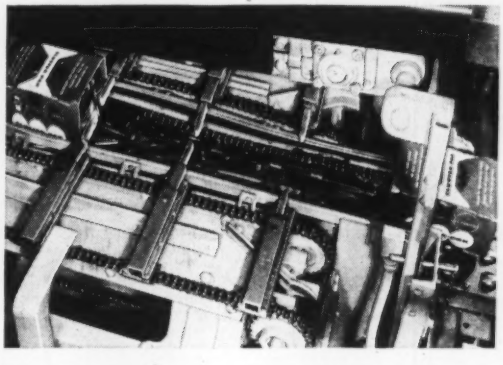
If you are interested in any of the above motors write and we shall be glad to send full information.

—ITEM 211—
For More Information Circle Item Number on Yellow Card—page 19

PACKAGING 900 CANS *per minute!*

Another complex timing and conveying problem solved through the use of

DIAMOND ROLLER CHAINS



ALWAYS PRELOADED For many, many years, Diamond Chain has been preloaded after assembly for the purpose of bringing pin-bushing seating into stabilized relationship prior to field installation.

Packaging cans from 3½ ounces to one quart sizes in single or double file and in cartons of from 2 to 12 units is an easy job for this versatile new Cluster-Pak* and its revolutionary cartons requiring no glue or staples.

The design of the machine incorporates Diamond Roller Chains for precision timing, power transfer and conveying. High output, dependable, low cost operation is essential—there can be no substitute for uniform highest quality Diamond Roller Chains.

On your machinery, Diamond Chain can simplify and improve design, permit easier, faster fabrication and assure outstanding performance . . . Diamond Engineers will gladly help you solve drive and conveying problems.

*"Cluster-Pak" is the registered trade mark of the Atlanta Paper Company

DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

DIAMOND ROLLER CHAINS

—ITEM 212—

For More Information Circle Item Number on Yellow Card—page 19

Duti-Rated Lifetime Gears

REDUCE OVERHEAD CRANE DRIVE COST 30%

Old gear train at left is large, cumbersome and inflexible. At right Foote Bros., designed gear train using Duti-Rated Gears—compact, light and efficient.

100% more capacity - 25% less weight - 28% less size

Ordinary commercial gearing in the traversing drive for an overhead, traveling crane system was bulky and had to be set at a space wasting 45° angle to save head room. Foote Bros. designed a special transmission system using Lifetime Duti-Rated Gears, permitting the application of smaller gears for the same capacity, allowing shorter center distances and a much more compactly designed drive.

The savings in space not only improved the design and performance of the overhead crane but also life expectancy. Maintenance requirements were greatly reduced. An outstanding feature of the new drive was that the Duti-Rated Gears could be interchanged on the same centers to change the ratios . . . allowing various speeds, fast and slow, for traversing.

This is only one example of what Duti-Rated Gears are doing in industry today. Extra gear capacity in less space . . . with longer life and lower costs . . . could be important to you, too. Call Foote Bros. today and learn all the advantages of Duti-Rated Lifetime Gearing . . . pre-engineered as standard or designed for your application. *FREE! Foote Bros. Engineering Manual "Duti-Rated Lifetime Gearing". Write for your copy today!*

This trademark stands for the finest industrial gearing made!

FOOTE BROS. Duti-Rated® LIFETIME GEARING

T.M. Reg. U.S. Pat. Off.

FOOTE BROS.

Better Power Transmission Through Better Gears

Foote Bros. Gear and Machine Corporation

4545 South Western Boulevard, Chicago 9, Illinois

—ITEM 213—

For More Information Circle Item Number on Yellow Card—page 19

There's more in this barrel than just a chemical

YOUR BIGGEST DOLLAR'S WORTH!

Excellence of product, excellence of service, and the experience, ingenuity and dedication of the organization make Parker surface treatments for metals the biggest dollar's worth in the field!

● The formulation is important in surface treatments for metals. Of equal importance, our customers tell us, are the extra services and qualities that are part of what you get with every barrel of a *Parker* surface treatment chemical.

There's over 40 years of *experience* in every Parker barrel . . . *engineering service* (without charge) to help fit the process into your plant . . . *fast availability* from plants located coast-to-coast . . . *experienced technical help* (Parker service men average over 12 years on the job) . . . continuing *research* which has pioneered developments in the field . . . *quality control, process lab* and *test facilities* which work to help customers improve their products.

For the finest metal surface treatments, plus all these advantages, call in the Parker man in your territory.

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel – Reg. U.S. Pat. Off.*

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

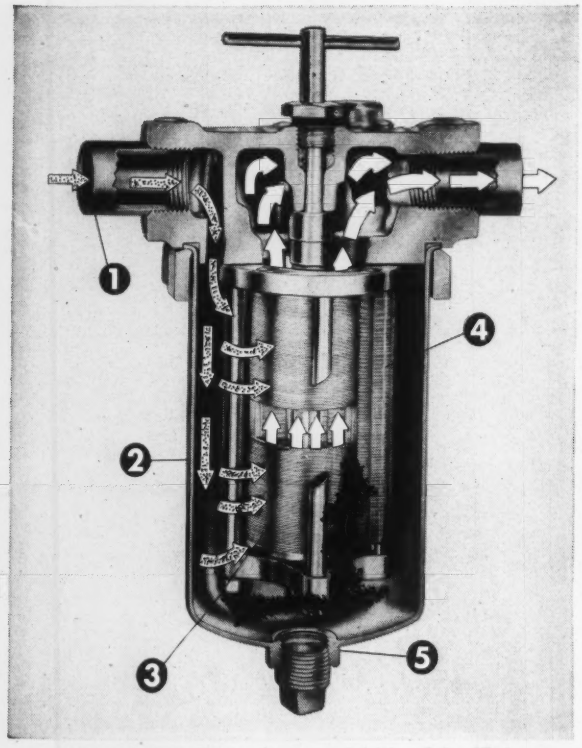
Since 1915— leader in the field

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

—ITEM 214—

NOW! 40-micron, self-cleaning filter

It's the new Cuno SUPER Auto-Klean



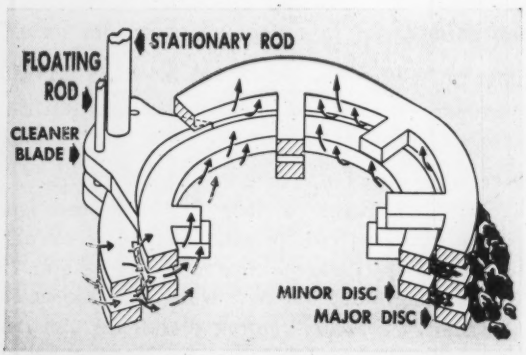
HOW IT WORKS. Dirty oil enters inlet (1) at left, fills housing (2) and flows through metal edge-type filter (3). Clean oil rises through center of filter, leaves at right. Dirt combed out by cleaner blades (4) is removed through drain (5).

Cuno's new SUPER Auto-Klean is the first practical, compact micronic filter for lubricating oil, hydraulic fluid, coolant, fuel, and other industrial fluids.

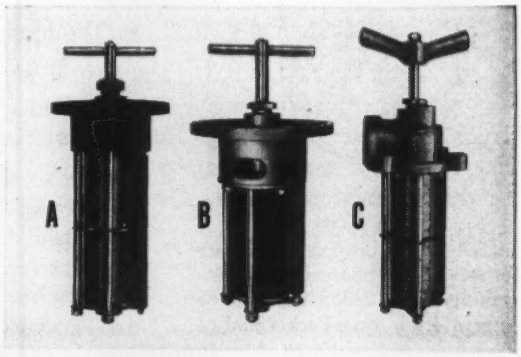
Many times smaller than other micronic filters of equal capacity, Cuno's new SUPER Auto-Klean filter now makes possible economical, micronic filtration at high flow rates and eliminates the need for replacement cartridges in most cases. Here's what it offers:

1. **Full-flow** 40-micron filtration with a self-cleaning filter. Positive protection against particles larger than 40 microns (actually 0.0015 in.). All-metal filter can't rupture or channel.
2. **Easy cleaning.** Just turn the handle—by hand or continuously with motor drive. No interruptions for cleaning.
3. **No cartridge changes.** Ends operating costs if you've been using cartridge filters.
4. **Low pressure drop, no pressure drop build-up.** An 8" by 2¼" SUPER Auto-Klean filters 30 gpm of 200 SSU oil with only 3 psi pressure drop—up to 75% more with slightly higher pressure.
5. **High capacity in a small package.** Many times smaller than replaceable-cartridge type filters of equal capacity, it saves with lower initial costs, lower installation costs.
6. **Easy to build into new equipment.** Available for line-type housings *(left)* or incorporation in sump or reservoir *(below.)* Works in any position.
7. **Easy to install in old equipment.** Fits existing Auto-Klean housings. You can easily replace most 2¼" diameter elements with SUPER Auto-Klean for finer filtration.

Write today for complete technical data on the new SUPER Auto-Klean for your new or existing equipment. Ask for Catalog No. SAK-057. Cuno Engineering Corporation, 14-2 South Vine Street, Meriden, Connecticut. 59



FILTER ELEMENT consists of stacked major and minor discs and cleaner blade bearing against minor discs. Small arrows show flow. Short restrictions between minor and major discs stop 40-micron particles but allow high flow rate.



FILTERS FOR INTERNAL PIPING *(A and B above)* allow streamlined design plus the best infiltration. Flange mounting with external outlet *(C above)* and line-type *(large cutaway above left)* are just a few of many other possibilities.

CUNO **ENGINEERED FILTRATION**

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous metal)

—ITEM 215—

For More Information Circle Item Number on Yellow Card—page 19

What is YOUR Control Problem?

AS MANUFACTURERS of a large and *diversified* line of major industrial equipment, Allis-Chalmers has been called upon to solve thousands of control application problems in practically every industry. This specialized experience in coordinating power utilization is *yours* when you specify Allis-Chalmers control.

Control for every ac application

Allis-Chalmers offers an extensive line of manual and magnetic control to meet every condition of motor operation. Control functions, varying with specific job requirements, include full or reduced voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking.

Custom protection

Built into all Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general purpose and special cabinet, including water-tight, dust-tight and explosion-proof enclosures.

A-4516

For complete information on any specific control problem, call your nearby Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wis.

ALLIS-CHALMERS

(Advertisement)

The world's largest opens a new era of

ABOUT one year ago, the largest die-casting machine in the world was completed and put into operation by Doehler-Jarvis Division of National Lead Company in cooperation with Kaiser Aluminum & Chemical Corporation.

Recently, the huge machine successfully produced the largest aluminum die-casting ever made—a six-cylinder in-line engine block weighing about 130 pounds less than a similar gray iron block.

The successful production of such a large and complex die-casting points the way to the design of large and economical die-cast aluminum parts for many industries.

Such parts would benefit from all the advantages of the die-casting process, which is inherently suited for mass production of parts requiring close dimensional tolerances, smooth surfaces, clean and sharp detail and thin metal sections.

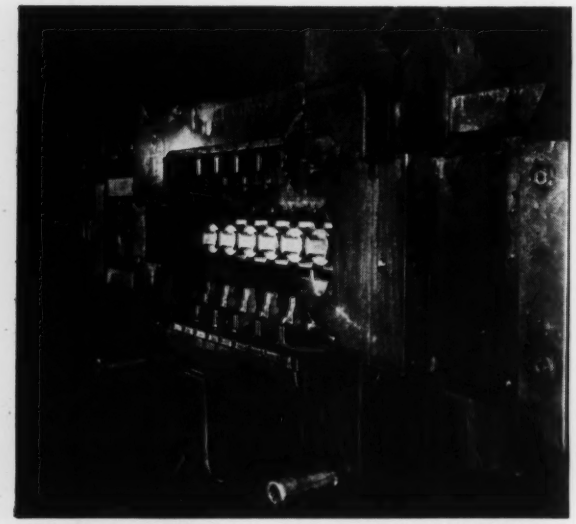
It is also possible to cast many details to size on the large press. In many cases, this eliminates the need to drill holes and other machining operations. Threads may often be cast to size, thus eliminating a threading operation. Cast-in metal inserts are readily included in die-castings.

Overall dimensional accuracy is another feature of die-castings that is important to many parts. This reduces the amount of finish allowance when parts are machined to a prescribed overall dimension.

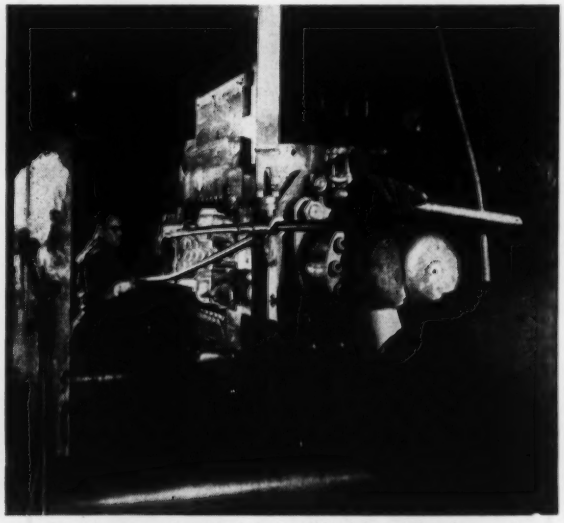
In addition, die-castings are generally lighter in weight than the equivalent parts made in sand or permanent mold, because thinner metal sections and less draft are permissible.

The metal quality of die-casting is more uniform than in a typical sand casting. Therefore, service life is more uniform.

Product designers and engineers should investigate this new Doehler-Jarvis Division of National Lead development in aluminum die-casting without delay to see if your existing or new designs can take advantage of the new 72" machine.

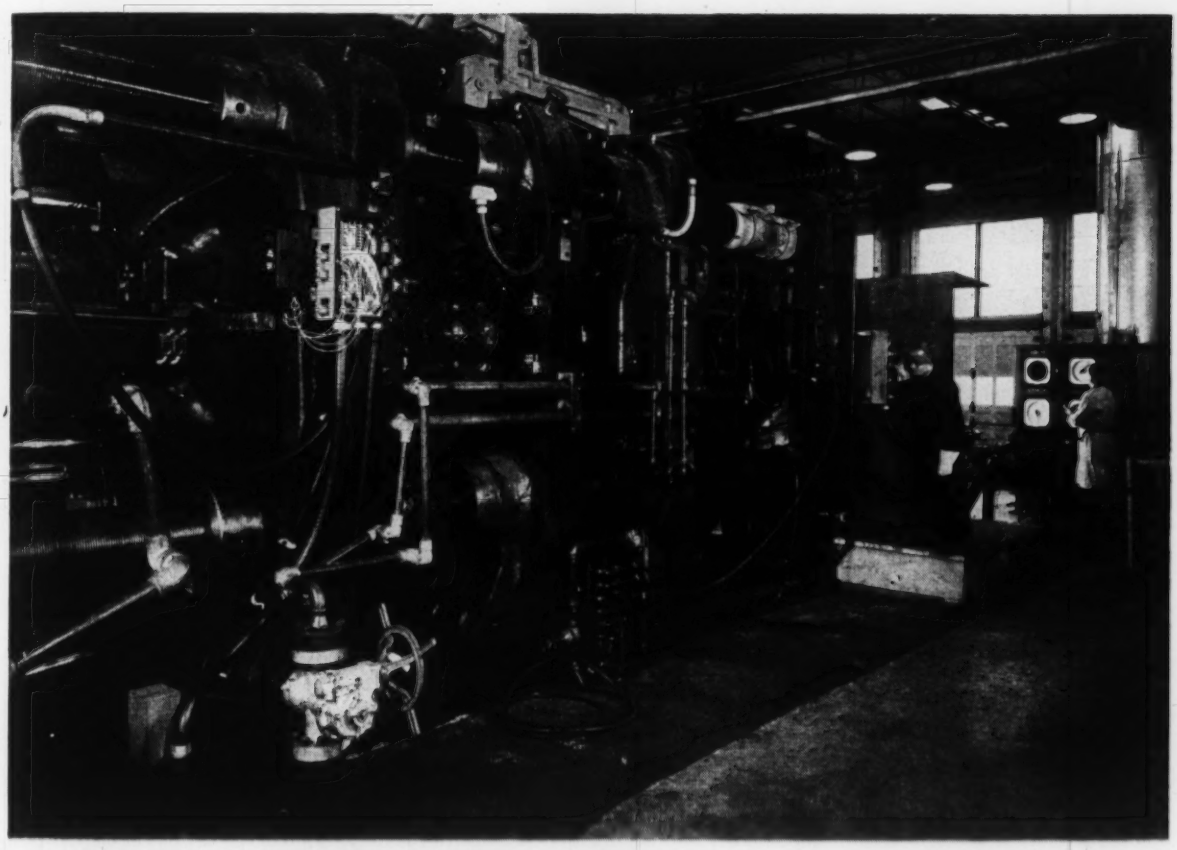


Machine open with dies for aluminum engine block in place.



Aluminum engine block being lifted from die after cast.

die-casting machine product design!



The new Doehler-Jarvis 72" die-casting machine – the world's largest – located at Toledo Plant.

Engine blocks were die cast by Doehler-Jarvis.

If you need assistance with aluminum . . .

Let us work in partnership with you. We are eager to share our knowledge of aluminum and engineering skill. Development engineers will gladly provide engineering service and counsel on design and alloy selection which may give you a better product at a lower cost. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California; DETROIT OFFICE, *1414 Fisher Bldg., Detroit 2, Michigan, Phone Trinity 3-8000.*

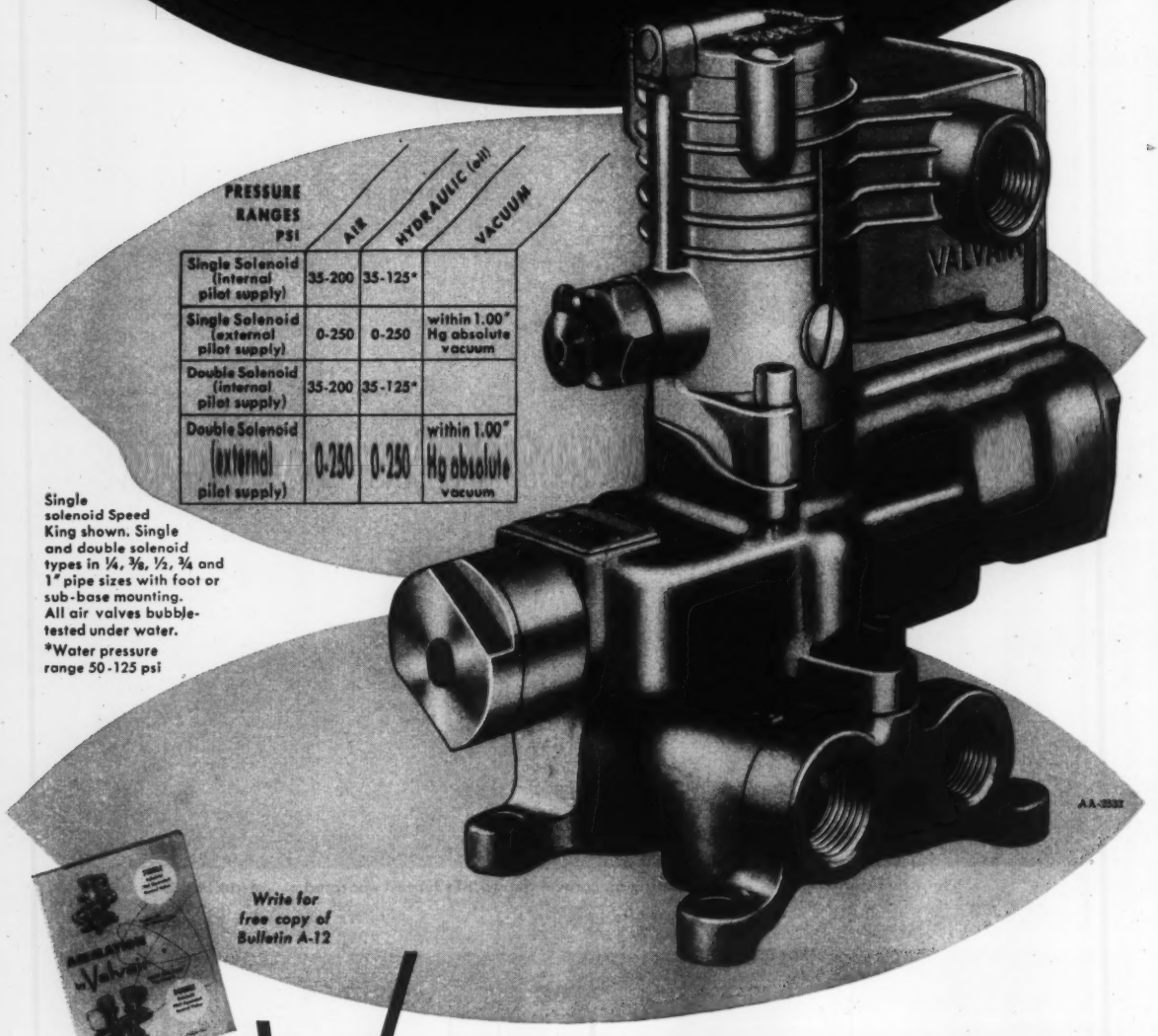
Kaiser Aluminum

setting the pace—in growth, quality and service

—ITEM 217—

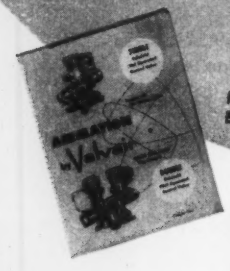
LONGER LIFE...NO COIL BURNOUT with SPEED KING

The valve that likes to be compared



PRESSURE RANGES PSI	AIR	HYDRAULIC (oil)	VACUUM
Single Solenoid (internal pilot supply)	35-200	35-125*	
Single Solenoid (external pilot supply)	0-250	0-250	within 1.00" Hg absolute vacuum
Double Solenoid (internal pilot supply)	35-200	35-125*	
Double Solenoid (external pilot supply)	0-250	0-250	within 1.00" Hg absolute vacuum

Single solenoid Speed King shown. Single and double solenoid types in ¼, ⅜, ½, ¾ and 1" pipe sizes with foot or sub-base mounting. All air valves bubble-tested under water.
*Water pressure range 50-125 psi



Write for free copy of Bulletin A-12

See us at the
ASTE Show
Chicago International Amphitheater,
MARCH 19-23
Space No. 130

Valvair

Compare the Speed King—by Valvair—with *any* valve. Check its design, features, materials of construction, and workmanship.

Be critical—check *performance*. For that's where the Speed King really scores. Up to 600 cycles per minute. And users report Speed Kings are still delivering satisfactory performance after 20 *million* cycles. What's more, Speed Kings are guaranteed against coil burnout for the life of the valve.

No matter what your requirements in air, hydraulic or vacuum control valves . . . compare and you'll specify Speed Kings—by Valvair. They perform better *longer*. Futhermore, immediate deliveries can be made from stock. Valvair Corporation, 454 Morgan Avenue, Akron 11, Ohio.

Representation In: Baltimore • Birmingham • Boston • Buffalo • Charleston, W. Va. • Chicago • Cleveland • Cranford, N. J. • Dayton • Denver • Detroit • Eureka, Calif. • Houston • Kansas City, Mo. • Logansport, Ind. • Louisville • Minneapolis • S. Pasadena • Philadelphia • Pittsburgh • Portland • St. Louis • Seattle • San Francisco • Syracuse • Montreal • Toronto • Vancouver

—ITEM 218—

MACHINE DESIGN
FEBRUARY 23, 1956

Broadening the Engineer's Horizon

ONE of the minor gripes of engineers is aimed at the lack of opportunity to attend professional meetings. Perhaps some management people are a trifle short-sighted in this respect.

It is true that the programs of many engineering meetings may not seem to offer specific help in solving current problems. It is also true that papers presented at meetings usually can be obtained in preprint form. So, why spend money to send a man to the meeting?

Such an attitude is indeed short-sighted. It fails to recognize the most important benefits accruing to a company which sends its men to national meetings. Mixing informally with fellow engineers from other companies and states, and participating in as well as listening to technical discussions, help broaden a man's perspective and develop him as a well-rounded professional operator of increasing value to his organization.

This spring, design engineers can look forward to at least two national meetings specifically tailored to their interests. On April 10 and 11 the Machine Design division of ASME will hold a conference in Worcester, Mass. On May 14 to 17 the same group will sponsor a conference to run concurrently with the Design Engineering show in Philadelphia. Of course, nonmembers of ASME are cordially welcome at both meetings.

Of particular and unprecedented interest are the Design Engineering show and conference in Philadelphia. For the first time in history an exposition has been planned to meet the specific needs of design engineers. Components and materials intended for incorporation in machines, appliances and equipment will be on display. And manufacturers' people will be on hand to discuss with engineers the potential uses of their products in applications of current significance.

Conference sessions, to be held each morning before show opening time, are being planned to have wide appeal. We have some personal interest in the conference, having been appointed to the program committee along with the editors of *Product Engineering, Electrical Manufacturing* and *Materials and Methods.*

To the benefits already outlined, this event adds the very tangible advantages of contact with suppliers of "hardware." Such contacts might well lead to substantial savings of engineering time and expense.

Here is an opportunity for design engineers to get out and rub shoulders with the rest of the engineering world, both professional and commercial.

Colin Carmichael

EDITOR

Digital Computers

THE MODERN high-powered digital computer, by virtue of its extremely high speed and practically unlimited data storage capacity, is causing a major change in the design philosophy in many engineering departments. The complete design of certain products, from customer specifications to shop manufacturing information, can now be performed automatically by such computers.

However, before any digital computer can be employed to design parts, equipment or complete machines, the design methods and associated data must be converted into a form the computer can accept. This conversion process or programming can be a time-consuming job. But once it is programmed, the high-powered computer can calculate many variations of the same design, and select the best from the standpoint of performance, cost, etc., in a matter of a few minutes. This facility is possible with a high-powered digital computer, such as the above IBM unit, because of its ability to follow a self-contained convergent trial-and-error iterative calculation procedure without any external consultation or supervision.

PROGRAMMING

In general, a digital computer can be or must be programmed to design equipment in accordance with the same design philosophy followed by an experienced engineer. Basic specifications of size, performance, etc., are used to calculate a set of initial input parameters by means of empirical formulas. Often the formulas may be based upon previous models of a similar design that have been built and tested.

The input parameters are used in the design method to determine a set of performance characteristics. Then, the calculated characteristics are compared with performance characteristics specified. If the calculated characteristics are not within the tolerance limits of the design specifications, the input parameters are modified and the calculation process is repeated until an acceptable design is obtained.

Organizing the design method and associated data for the computer requires that a flow chart be developed and a complete step-by-step mathematical outline be made of the method. The flow chart is a graphical representation in block form of the design procedure.

First, a general block flow chart is constructed to illustrate the major accomplishments of the computer program and any iterative loops, *Fig.* 1. Next, a separate block flow chart for each major

s in Design

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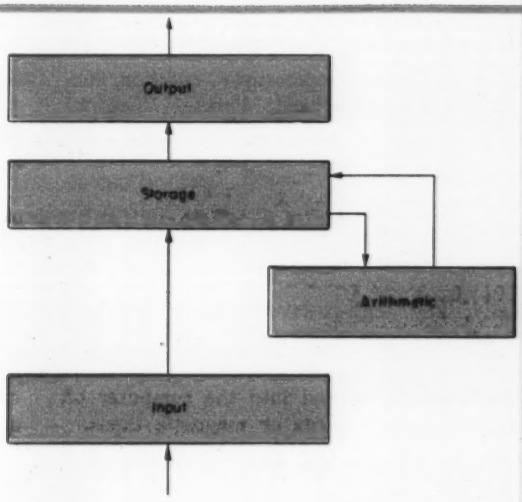


Working at fantastic speeds, both digital and analog computers—large and small—are proving their worth every day in disposing of all kinds of computational chores. Months or even years of calculations are being compressed into minutes or days.

Computers can and are being increasingly put to work in various phases of design.

But the answers computers give obviously are only as good as the design formulas fed to them. And the choices some of them can make are no wiser than the criteria established by the designer.

This article shows how high-powered digital computers are being used in the high-speed design of lines of equipment that

1. Must satisfy a variety of customer performance requirements.

2. Are subject to a number of complexly interrelated physical laws or equations.

3. Are built from a variety of types of components, many of them standard and, hence, available in discrete increments only.

accomplishment in the general flow chart is constructed. It graphically represents every operation and logical decision described in the mathematical outline, *Fig.* 2. The step-by-step mathematical outline must contain the mathematical relationships of all equations, curves, etc., to be used in the design method. Also, the designer must record in logical sequence all the decisions made during the course of a design.

Fulfilling this last requirement is by no means a simple matter. The design engineer must rely on all his ingenuity and design intuition to develop a set of rules for modifying the input parameters whenever certain calculated performance characteristics do not meet design performance specifications. Based on a specific performance disagreement pattern, the designer must determine which input parameter to change and in which direction.

This setting-up of choices requires a careful and extensive study of the design process, but is essential in designing products over the entire range of possible product ratings, sizes, etc., with a computer.

The flow chart and the mathematical outline are used to program or convert the mathematical relationships and logical decisions of the design method into the basic computer operations. Actually, a high-powered digital computer is capable of performing only simple logical and arithmetical operations. Its tremendous advantage stems from its ability to perform these simple operations at in-

credible speeds. Hence complex lengthy mathematical equations that are expressible in terms of the basic arithmetical operations—addition, subtraction, multiplication, and division — can be solved in a reasonable period of time.

After the program *has been written* for all the design equations and their associated logical decisions, this information is *read* into computer.

DIGITAL-COMPUTER ELEMENTS

Basically, any high-powered digital computer consists of four main components: input, output, storage and arithmetic units.

Information can be read into the computer on paper tapes, punched cards or magnetic tapes.

Results of a computation can be obtained from the computer on paper tapes, punched cards, magnetic tapes, a cathode-ray tube screen, or printed on paper.

Data and instructions can be stored in the computer in magnetic cores, on magnetic drums or magnetic tapes. Because of the high speed with which information can be read to and from the magnetic-core storage, it is used in conjunction with the arithmetic unit. Programs are stored in block form on the magnetic drums or tapes and are read in this form into the magnetic-core storages whenever the computer is required to execute that particular program.

High-speed storage registers, multiplier-quotient register, instruction register and the accumulator combine to form the arithmetic unit.

The high-speed storage registers hold the information involved in current calculations. The multiplier-quotient register contains the multiplier in any multiplication operation and is the register in which the quotient is developed during a division. The instruction register contains directions for the computer operation. Over-all instructions are stored in sequential storage locations and are executed in the same order. The accumulator is an adding register in which the sum or difference of any two numbers can be obtained. It is also used to hold the dividend in division.

BASIC COMPUTER OPERATIONS

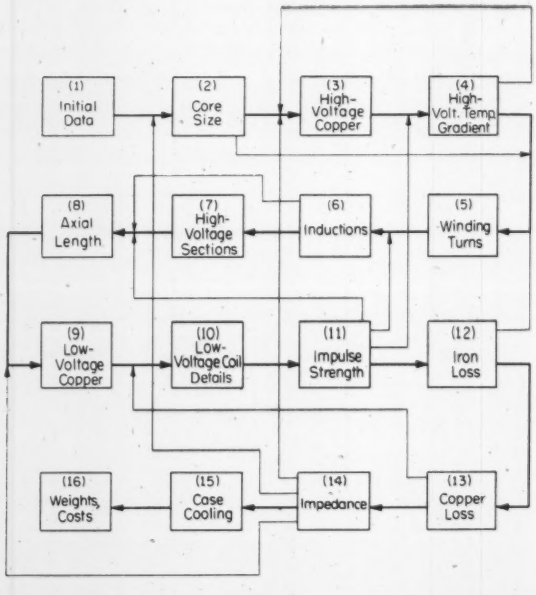
A modern high-powered digital computer is capable of performing over 80 simple arithmetic and logical operations. Hence, each mathematical expression in every design equation must be reduced to one or more of these simple basic operations. If the mathematical expression involved is not included in the existing computer operations, then it must be reduced further or expressed in another form. For example, the design equation might require the square root of the number, A. Finding a square root in conventional fashion is not one of the basic digital-computer operations. However, a square-root can alternately be expressed by the convergent iterative equation,

$$\sqrt{A} = N_{i+1} = \frac{1}{2}\left(N_i + \frac{A}{N_i}\right)$$

where N_i is the ith approximation of the square root of A, and N_{i+1} is the $(i + 1)$th approximation of the square root of A. Every operation in this equation is included in the basic digital computer operations. When this set of operations has been programmed, it is usually stored in some portion of the computer memory. Such a program is called a *subroutine*. Henceforth, whenever this same expression is required, use may be made of the existing general program.

In a general block flow diagram of a design process, the square-root operation would appear as shown in *Fig. 2a*. This same subroutine is expanded by the computer programmer to the form illustrated in *Fig. 2b*. Blocks 1 through 7 are operations of basic arithmetic, while Block 8 is a decision (logic) element. If the results of the calculations of Block 7 are not equal to zero, the

Fig. 1—Typical block flow diagram used for programming digital computers for complicated equipment designs. This one provides computer design data for power transformers



computer returns to Block 1 and repeats the sequence of operations until $N_{i+1} - N_i = 0$. The computer goes to the next instruction when the subroutine result is equal to zero.

This square-root subroutine illustrates the meaning of the flow chart and the steps necessary to reduce a mathematical operation to the basic digital computer operations.

Although digital computers can execute a program in a matter of minutes, programming can be a major task in some instances. However, with a rational design process—and adequate effort—it can be done. Once written, these programs can be used for months or even years, except for minor revisions and improvements.

DESIGN APPLICATIONS

Certain lines of products are definitely more suitable for taking full advantage of high-powered digital computers than others. Large standard-line core-form power transformers and large induction motors are excellent examples. Transformers of this type are basically similar and, yet, almost all are custom designed. With the known practical ranges of performance, size, etc., programmed into a computer plus production limitations and manufacturing codes, final working electrical design data can be obtained in minutes. At Westinghouse, transformers have been designed with digital computers over a range of 750 to 20,000 kva. Also, induction motors have been computer designed with ratings over a range of 200 to 2000 hp.

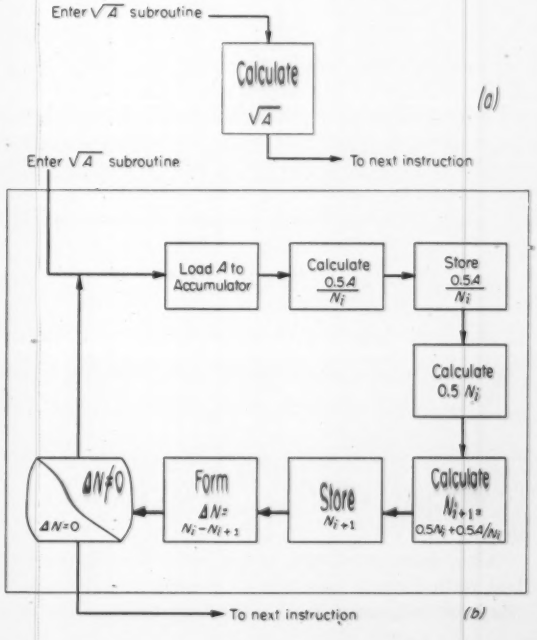
Transformer Design: The digital computer "designs" transformers using the same philosophy as that followed by an experienced engineer. Once the input information, such as kva rating, basic impulse level, temperature rise, etc., has been entered into the computer, it initially selects or assumes certain design parameters necessary to calculate performance characteristics. These characteristics are then compared with the specified guarantees. If calculated values exceed those guaranteed, the initial assumptions are revised and the process repeated until a favorable design is produced.

A total of 16 subroutines are used by the computer to design a transformer such as shown in *Fig.* 3. Their relative operational position in the computer program is illustrated by the general block flow diagram in *Fig.* 1. The first subroutine includes all items generally specified by the customer, such as maximum temperature rise, winding connections, impulse levels, etc. Subroutines 2 through 10 deal with design parameters, which are the quantities to be varied in order to produce an acceptable design. Subroutines 11 through 14 represent the test criteria based on the specified guarantees. Subroutine 15 permits the computer to calculate the type and amount of external cooling equipment required to maintain the operating temperature of the transformer below the allowable maximum. Weight and cost of the transformer are determined with Subroutine 16.

The computer begins to obtain transformer design data by first selecting a core size with empirical formulas based on kva ratings and the basic impulse level. High and low-voltage windings are selected to complete the initial transformer design in Subroutines 1 through 10 in *Fig.* 1. The design is next checked for impulse strength in Subroutine 11. If the initial design fails to meet the impulse strength criterion, corrective changes are made in the proper design parameter and the test applied again. The operation is repeated until the impulse strength criterion is satisfied.

The iron and copper losses are than calculated. The maximum allowable iron loss for a given core size can be obtained by programming to obtain the maximum allowable induction. The copper loss is varied by increasing or decreasing the size of the wire in the proper winding. When these two results satisfy the guarantees, the impedance

Fig. 2—Subroutine in a general block flow diagram for calculating the square root of A is shown in *a*. In *b* is the expanded form of this subroutine showing the seven arithmetic steps and the one logic step involved



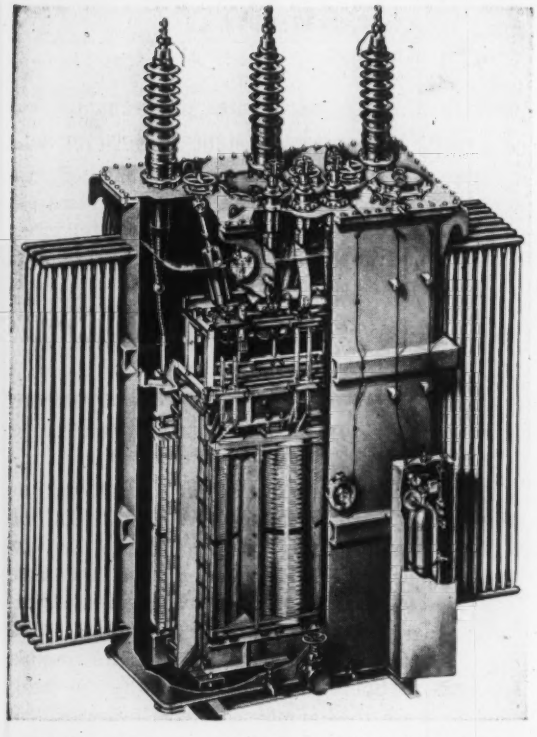


Fig. 3—Power transformer which has been programmed for automatic design by digital computers. Once performance, size, etc., have been programmed into a computer, it can provide working design data in a few minutes

is calculated in Subroutine 14. If the calculated impedance does not correspond to the guarantee, the physical proportions of the existing design may be changed or a new core size selected. The latter alternative means that an entirely new design must be made. After the proper impedance has been obtained, cooling, weight, and cost are calculated to complete the transformer design.

Induction-Motor Design: Thus far, only standard-line induction motors are being designed by digital computers at Westinghouse. This line uses a discrete number of frame sizes which have definite stator and rotor diameters, slot dimensions, air gaps, etc.

Again the trial-and-error process is employed. The computer first calculates an initial D^2L value from an empirical equation based on horsepower and pull-out torque. The D^2L value is an arbitrary design parameter used to obtain a first approximation of machine size in terms of diameter and length. The computer is programmed to select a diameter starting with the smallest frame size and obtains a length based on the calculated D^2L. If the determined length lies outside the range of lengths specified on that particular frame size, the next frame diameter is selected and the process repeated.

When an acceptable rotor length is obtained, the temperature rise of the rotor during starting is calculated. Temperature rise tells whether there is sufficient slot volume to prevent the damper bars from overheating during starting. The length is increased by small increments until sufficient volume is obtained.

With a suitable diameter and length established, the associated induction-motor constants, such as the iron depth below rotor and stator slots, the iron area between adjacent rotor and stator teeth, etc., are calculated for use in the various performance equations.

At this point, a flux density is calculated by equating one of the performance equations to its required design guarantee. This density is then substituted into the remaining performance equations to determine the remaining characteristic of the particular motor.

If the calculated density when substituted into the remaining equations fails to produce a result that meets the required design specifications, a new flux density is obtained and the calculation repeated. If there exists any one density or set of densities that satisfies all the performance requirements, an acceptable design results. If no density satisfies all of the performance criteria, the length is increased and the process repeated. When a suitable density is established, a winding is selected that will produce the required density at the proper line voltage.

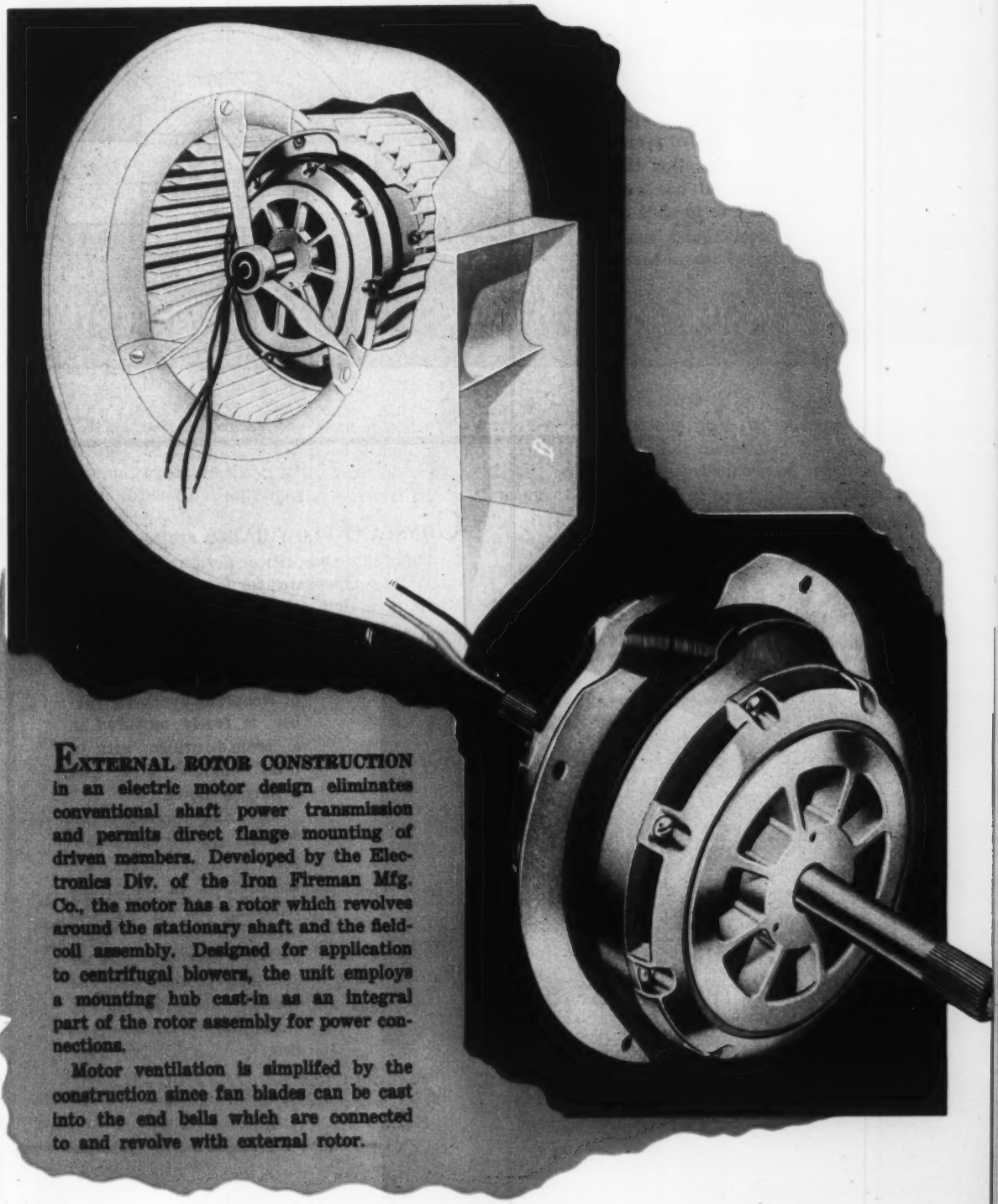
ADVANTAGES

Saving of design time is the most obvious advantage in the foregoing applications of digital computers. But another corollary factor is of prime importance, also. The computer aids exhaustive study of each design to make certain that performance specifications are being satisfied at minimum manufacturing cost, and with no delay.

Also, computers can be used in the analysis of test data from a new line of products to determine the best relationship of design parameters to performance characteristics. Thereby basis is provided for the best design possible.

Perhaps in the long run the greatest gain is measurable to designers themselves. Computers serve to extend their capacities by taking over time-consuming and often tedious computations. Time so gained can be put to use on other more creative work, often to a designer's personal advantage. And each increment of engineering time saved by computers goes a bit of the way in extending available engineering manpower.

scanning the field for *Ideas*

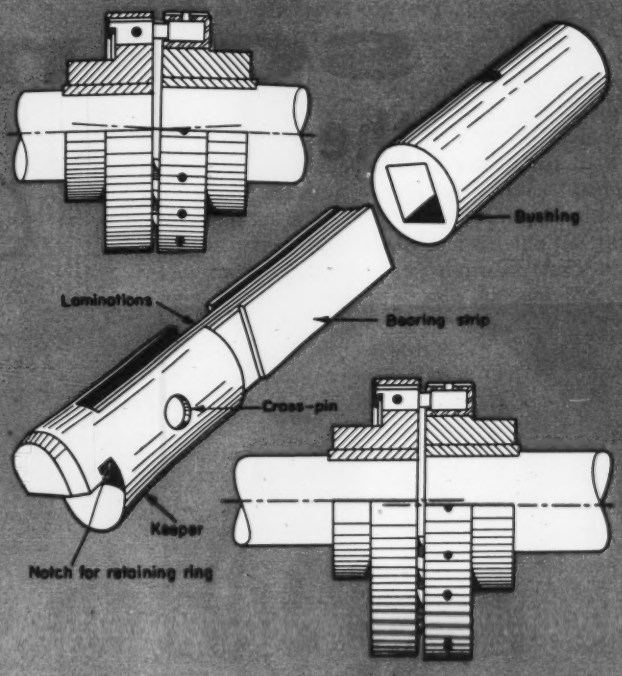


EXTERNAL ROTOR CONSTRUCTION in an electric motor design eliminates conventional shaft power transmission and permits direct flange mounting of driven members. Developed by the Electronics Div. of the Iron Fireman Mfg. Co., the motor has a rotor which revolves around the stationary shaft and the field-coil assembly. Designed for application to centrifugal blowers, the unit employs a mounting hub cast-in as an integral part of the rotor assembly for power connections.

Motor ventilation is simplifed by the construction since fan blades can be cast into the end bells which are connected to and revolve with external rotor.

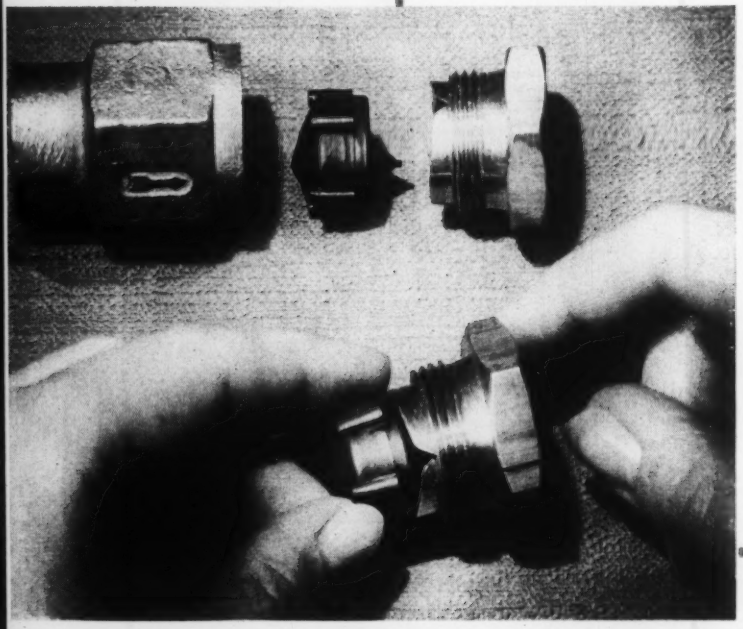
IDEAS

LAMINATED SPRING PINS in an all-metal coupling assembly absorb shock and vibration, and accommodate axial misalignments. Employed as power transmitting elements in couplings made by Smith and Serrell Inc., the flexible pins are made up of high-grade steel laminations with thick hard-steel bearing strips welded to the outside layers. One end of the laminations is held in a keeper with a cross-pin which permits a limited pivoting action. In operation the pins can flex, and one end of each pin is free to slide in and out of rectangular holes in self-lubricated bronze bushings.



CONSTANT FLOW RATES are assured by a diaphragm-and-orifice design that automatically compensates for inlet pressure variations in a flow control valve manufactured by the Hays Mfg. Co. The diaphragm, which is made of Neoprene synthetic rubber, is freely mounted in a bronze orifice with a broad shallow V-cut and a narrow notch.

As inlet pressure increases, the synthetic-rubber diaphragm flexes into the broad V of the orifice reducing the opening and throttling flow. When pressure decreases, the diaphragm relaxes and the opening is enlarged to maintain constant flow rate.



Designing with Nylon

Practical recommendations for engineering design of nylon parts

Part 1—Working Stresses; Time and Environmental Effects

By A. J. Cheney
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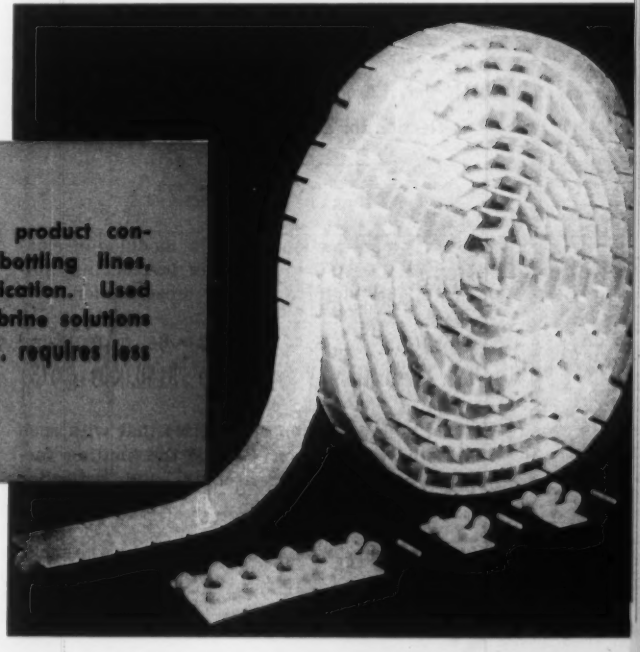
PLASTICS are affected by the same physical laws and the same rules for good design as other materials. Properties to consider and values to use depend not only on the material but also on the application itself. It is necessary to know or have a reasonable estimate of what the end-product must do and under what circumstances it functions. Then plastic parts or objects—including nylon parts—can be designed to meet performance specifications just as successfully as parts made of any other material.

Let's look at basic principles of machine design and the properties of nylon plastic needed to solve most design problems. Properties given are for Zytel 101 (formerly FM 10001), the type most commonly used for mechanical applications.

Failure Criteria: Much of design may be defined



Flat-top conveyor belt of nylon helps avoid product contamination by lubricants in canning and bottling lines, since the conveyor can operate without lubrication. Used where corrosion by food acids, alkalies and brine solutions is a problem, the belt produced by Fenco Inc. requires less power because of its light weight

as a search for potential causes of failure—so that the cause of failure can be eliminated. An object or part may fail by: (1) breaking, (2) deforming, (3) wear, or (4) chemical attack. Normally, for a given application, only one of these factors is limiting; it determines the design.

Let's examine the first two causes of failure. A part under load breaks when the stress developed at some point exceeds the strength of the material there. It fails by deforming when the deformation results in the part not being able to function as required.

On a stress-strain curve, stress is measured in pounds per square inch, and unit deformation, or strain, in per cent or in inches per inch. A typical stress-strain curve for nylon is shown in *Fig.* 1.

As tensile stress on the test bar is increased, the strain or elongation increases proportionally up to approximately 3000 psi. At higher stresses the elongation becomes proportionally greater until at the yield point the bar elongates under no additional load.

The yield point for Zytel 101 is 8000 psi at 25 per cent elongation. Beyond the yield point, the test specimen necks down which results in a high elongation before rupture. In spite of the reduction

Table 1—Strength and Deformation Calculation Example

Vertical pins are to be designed for use in a commercial dish washer conveyor. They will be exposed to water at a maximum temperature of 180 F. The pins should be 4 in. high to hold the trays and dishes vertical for draining and could have a maximum sideways (cantilever) load of 10 lb each at the top. What size pin should be used?

Properties of Zytel 101 in water at 180 F are: tensile strength, 4500 psi (*Fig.* 2); and modulus of elasticity, 40,000 psi (*Fig.* 3). With a safety factor of 4, the working stress = 4500/4 = 1100 psi.

Round Pin: Assume that a round pin will be used. To design for strength, the bending equation (concentrated load) for a cantilever beam is

$$Fl = SZ \text{ or } Z = \frac{Fl}{S}$$

where Z = section modulus, in.^{3}; F = force, lb; l = moment arm, in.; and S = working stress, psi. Then $Z = 10(4)/1100 = 0.036$.

For a round cross section, the section modulus

$$Z = \frac{\pi D^3}{32}$$

where D = diameter of the pin, in. Since Z = 0.036-in.^{3}, the diameter of the pin D = 0.72-in.

Deflection for a round beam

$$Y = \frac{Fl^3}{3EI}$$

where Y = deflection, in.; E = modulus of elasticity, psi; and I = moment of inertia, in.^{4} Moment of inertia for a circular cross section, $I = \pi D^4/64$.

For this pin, $I = \pi\ (0.72)^4/64 = 0.013$-in.^{4}

Then deflection $Y = 10(4)^3/3(40,000)(0.013)$ = 0.41-in.

This high deflection emphasizes that with such parts the deformation may be the limiting factor rather than the strength, and deflection should be checked.

Other Shapes: A round pin is not the most economical structure to resist bending; a rectangular or I-beam section would be stiffer. There is room in the conveyor for such a section but the maximum dimension in the direction opposing the force is 1¼ in.

Assume that a deflection of ⅛-in. is acceptable. Then the thickness of a rectangular support can be found by solving for the moment of inertia, I, in the equation for deflection: $I = Fl^3/3EY = 10(4)^3/3(40,000)(0.125) = 0.043$-in.^{4}

Thickness of the support can then be determined from

$$I = \frac{bh^3}{12} \text{ or } b = \frac{12I}{h^3}$$

where b = thickness, in.; and h = width. In this case, $h = 1.25$ in., and $b = 12(0.043)/(1.25)^3 = 0.265$-in.

It can also be shown that an I-beam with ⅛-in. thick webs having outside dimensions of 0.412 by 1.25 in. will deflect the same as the rectangular pin. And if size of the round pin is recalculated for 0.125-in. deflection, diameter will be found to be nearly 1 in.

Summary: For the three types of pins, with a permissible deflection of 0.125-in., sizes and amounts of material required are:

Pin	Size (in.)	Material (cu in.)
Round	0.97 diam	2.94
Rectangular	0.265 by 1.25	1.33
I-beam	0.412 by 1.25 (⅛ web)	0.91

The importance of shape selection on material cost (and performance) is apparent. In addition, the I-beam section can be molded on a faster cycle.

The injection molding process not only offers the opportunity to core out sections like the I-beam but also permits ribs to be used to strengthen sections at little additional expense. The part should be designed so that material is where it is needed. Then, if necessary, it should be modified to fit good molding practice.

in cross-sectional area, the drawing strengthens the material so that the final break is usually at a higher stress — at 9300 psi calculated on the original area and 220 per cent elongation in this case.

Stress-strain data tell two things—the strength of the material and how much deformation takes place at any given stress at this rate of loading. Here's how these data can be used in practical design work.

Strength Calculations: As with most materials, no portion of a nylon object should be stressed beyond the yield point. For practical design work, even lower working stresses are used.

The working stress can be found by dividing the tensile strength by a factor of safety to reduce the actual stress to a value below the yield point. The factor of safety for a given application depends upon (1) uncertainty in predicting performance requirements, and (2) seriousness of failure if it should occur. Normally, it is between 4 and 10.

For example, if ½-in. ID tubing made of Zytel 101 nylon resin is to carry air at a maximum pressure of 250 psi, what wall thickness is required? The equation for wall thickness of thin-walled tubing is

$$t = \frac{PD}{2S}$$

where t = wall thickness, in.; P = internal pressure, psi; D = inside diameter, in.; and S = working stress, psi.

The type of loading and other end-use requirements can be predicted accurately; however, a rather high margin of safety is required because a possible failure would result in high maintenance costs compared to the cost of the tubing. Therefore, the factor of safety should be taken as 8. Working stress is the tensile strength, 9300 psi, divided by the factor of safety, 8, or approximately 1200 psi. Thickness is $t = (250 \times 0.5)/(2 \times 1200) = 0.052$-in.

Another typical stress calculation is shown in *Table* 1.

Under different circumstances the factor of safety might be taken as 6 or 10. The same consideration is given to selecting a safety factor here as with metals or other construction materials.

Deformation Calculations: When a load is applied to any material, some deformation results. A part will fail if the deformation is large enough so that the part can no longer perform as required.

Resistance to deformation, or the stiffness of a material, is measured by the modulus of elasticity —a higher modulus meaning that the material will deform less under a given load. By definition, the modulus is the slope of the stress-strain curve, *Fig.* 1, at lower stress values where the curve is a straight line, or stress divided by strain in this elastic region. For average air exposure and room temperature, the modulus of elasticity of Zytel 101 nylon resin is 200,000 psi.

In the tubing previously calculated, the circumferential strain at a stress of 1200 psi will be 1200/200,000 = 0.006-in. per in.

The modulus also appears in calculations such as those used in determining the deflection of beams, *Table* 1. It is of much more value in design work than specific stiffness tests that are limited to certain shapes or mounting conditions.

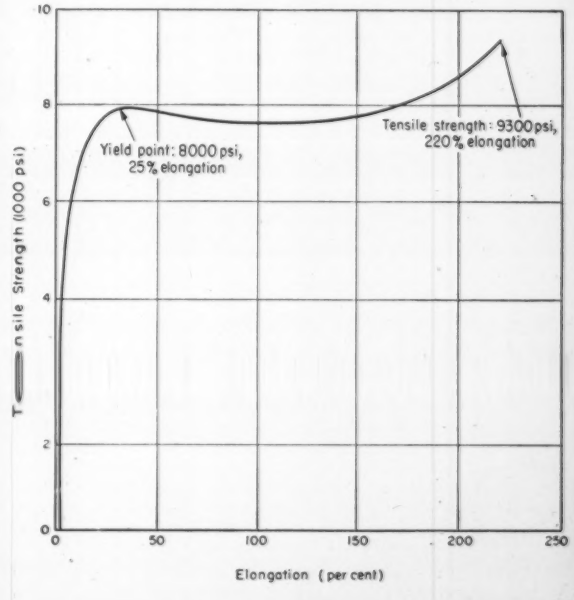
Obviously, from the stress-strain curve, modulus values cannot be used to predict deformation accurately at stresses beyond the straight-line portion of the curve—in this case at stresses above approximately 3000 psi.

Environment: Properties of all materials vary with temperature. In addition, properties of nylon resin will depend upon moisture content of the polymer.

Nylon will not deteriorate from exposure to either fresh or salt water. This has been demonstrated by many successful industrial applications and by its use in sports equipment such as fishing reels. However, nylon is hygroscopic; that is, it will absorb moisture from its surroundings until, in time, an equilibrium is reached. Thus, for average air exposure, Zytel 101 will absorb moisture until approximately 2.5 per cent by weight is moisture, while immersion in water increases the value to 8.5 per cent.

In order to mold good quality parts, molding powder containing less than 0.3 per cent moisture

Fig. 1—Tensile stress-strain curve for nylon (Zytel 101 conditioned to 73 F and 50 per cent relative humidity)



is normally used. Thus, the part as molded has a relatively low moisture content. It will then slowly absorb moisture until equilibrium is reached. These hygroscopic properties are similar to those of natural materials like cotton and wood, although the equilibrium water content of nylon resin is much less.

Pickup of moisture after molding greatly improves toughness and impact resistance but reduces strength and stiffness. Tensile strength of Zytel 101 for various temperatures and moisture conditions is shown in *Fig.* 2. Since strength is reduced at higher temperatures and moisture contents, the working stress used in design should be based on the tensile strength value at the maximum temperature and moisture content expected during the life of the part.

Similar data on the modulus of elasticity are shown in *Fig.* 3. The importance of selecting the correct modulus is apparent from the magnitude of the change with environment. A part will be twice as stiff as-molded as at equilibrium with average air conditions (air at 50 per cent relative humidity). On the other hand, for hot and wet applications quite often encountered, stiffness or resistance to deformation is considerably less.

When a change in properties due to the change in moisture content is important to the operation of a part, the molded pieces should be conditioned to a moisture content close to the expected equilibrium value. Then, particularly in air applications, variations in the environment will cause little change because the rate of moisture absorption or loss near to equilibrium conditions is very slow. Recommended methods for moisture conditioning will be discussed in Part 2 of this series.

Increasing the temperature shortens the time to reach equilibrium but does not change the amount of water absorbed. For instance, 8.5 per cent will be absorbed by soaking parts in room-temperature water. The same amount is absorbed in boiling water, but the time required is much shorter.

Fig. 2—How moisture and temperature affect tensile strength of nylon

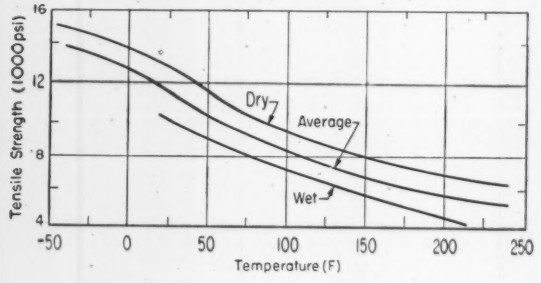
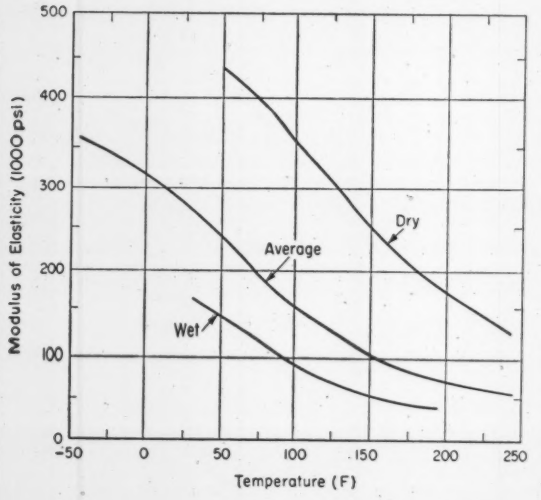


Fig. 3—Change in modulus of elasticity with temperature and moisture content



Compression and Bending: Tensile stress values are usually used as a basis for design of parts under other types of stresses. This applies equally well to nylon resin as demonstrated by Marin[1], who showed that the magnitude of the deformation under a given stress is essentially the same whether the material is under tension or compression, *Fig.* 4. Therefore, the modulus of elasticity can be used in compression and bending calculations.

Deformation with Time: One design factor less frequently encountered with metals than with plastics is continued deformation with time—normally called creep or cold flow. A part that is to be under a long-time stress must be designed so that deformation with time will not be excessive or so that fracture will not occur. For most design problems this can be accomplished easily.

Creep-time relations for nylon at various stress levels have been determined.[1] Typical data for Zytel 101 nylon for both tension and compression are shown in *Fig.* 4.

When stress is applied, there is first an elastic deformation which at 1800 psi would equal approximately 0.009-in. per in. Then there is a period of transitory deformation ending at 100 hr or less. Beyond this, the deformation is essentially a straight-line function of the time.

One important fact apparent from these data is that the major deformation takes place in approximately 24 hr. This fact is of particular value in setting up tests to check the performance of specific parts under load. Total deformation at the end of 24 hr will be approximately 75 per cent of that obtained at the end of 1 year. Creep after 1 year is so small that for all practical purposes it can be neglected. Thus, short-term tests can usually predict the results to be expected after longer periods under load.

In short-term tests, moisture content of the material must be close to expected equilibrium con-

[1] J. Marin, A. C. Webber and G. F. Weissmann—"Creep-Time Relations for Nylon in Tension, Compression, Bending, and Torsion." *Proceedings*, American Society for Testing Materials, Philadelphia, Vol. 54, 1954, Pages 1313-1329.

ditions for the end use.

Several methods for utilizing these data in design work are possible. The most practical appears to be to use a lower modulus value—depending upon the time—in deformation calculations.

For instance, in *Fig.* 4, the material has an initial modulus of 200,000 psi. In 100 hr, however, the material has behaved as though the modulus were 114,000 psi. In other words, the deformation expected in 100 hr for a stress of 1800 psi is 1800/114,000 or 0.016-in. per in., and at 450 psi is 450/114,000 or 0.004 in. per in. Differences between the curves are well within experimental error.

A reduced value for the modulus, used to compensate for the effect of time, can be called an apparent modulus. A plot of the apparent modulus versus time for Zytel 101 nylon resin at moisture equilibrium with average air exposure is shown as a solid line in *Fig.* 5. Since modulus is independent of stress below 3000 psi, these values for apparent modulus can be used to determine total deformation for any stress below this value.

Suppose a ¼-in. thick section is to be under a compressive stress that may be applied continuously for a year. A maximum deformation of 0.008-in. can be tolerated. What stress should be used in sizing this section?

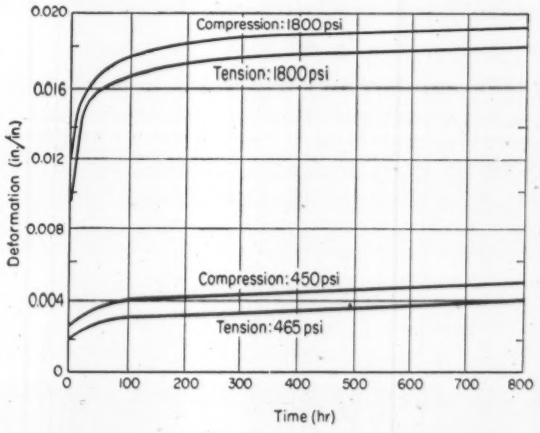
A deformation of 0.008-in. for a ¼-in. thick section gives a unit strain of 0.008/0.25 = 0.032-in. per in. The apparent modulus at 1 year is 95,000 psi. By definition, stress = modulus × strain = 95,000 × 0.032 = 3000 psi. Caution in use of this stress value would, however, be in order since, from *Fig.* 1, the stress-strain curve above 3000 psi is not a straight line so that allowance has to be made for additional deformation if higher stresses are used.

Change with time for other values of the modulus can be estimated safely by using the dotted lines in *Fig.* 5. For instance, in a hot and wet application, where the initial modulus might be 100,000, the bottom dotted line is an estimate of the apparent modulus with time.

Questions are often raised about the amount of deformation that can take place before fracture will occur. For steady loads, the material will draw down, as previously described, so that very high elongations are usually obtained. Short-time creep tests at higher stresses, for instance, show the time to reach 50 per cent elongation is 47 hr at 5000 psi, 1000 hr at 4500 psi, and is estimated to be 4.5 years at 4000 psi. Normally, a high deformation can be tolerated by the material—deformation that will usually make the part inoperative before actual rupture occurs.

Deformation Recovery: Cyclic tests on Zytel 101 nylon resin have also been run[1], with a stress applied for 1 hr and then removed for 1 hr, that

Fig. 4—Creep-time relations for nylon



Near-zero spring rate is provided in nylon bellows used in sensing units built by Simonds Aerocessories Inc. for explosion and fire-suppression devices. Used primarily in jet aircraft fuel tanks, the bellows must react quickly to change in pressure caused by an incipient explosion. The bellows then closes a circuit to operate a mechanism which releases a mist of suppressant, all within a few milliseconds. Nylon resists corrosive effects of jet fuel vapors

showed the rate of recovery from deformation. Deformation at the end of 1 hr at 1800 psi was 0.0095-in. per in. When the stress was removed, the test piece recovered to a total deformation of 0.002-in. per in. immediately. At the end of the 1-hr rest, the deformation was down to approximately 0.0005-in. per in. Repeated loading resulted in the new deformation being superimposed on the remainder of the previous change.

After three complete cycles, the total deformation was 0.001-in. per in. Applying a stress of 1800 psi again resulted in a total deformation in an hour of 0.0105-in. per in. At the end of an hour at rest deformation was slightly over 0.001-in. per in.

Longer rest periods showed that the recovery continues but at a reduced rate. For instance, after four cycles at 1800 psi, as just described, the deformation had reduced from 0.001 to approximately 0.0006-in. per in. in 16 hr at rest.

For design purposes, the maximum deformation to be expected can be calculated using the apparent modulus as determined by the total time under load. Thus for four 1-hr cycles at a stress of 1800 psi, the apparent modulus, *Fig.* 5, would be 160,000 for the 4 hr under load. The calculated deformation is 1800/160,000 or slightly over 0.011-in. This checks with the 0.0105-in. deformation actually measured.

To be on the safe side, the immediate recovery upon removal of the load can be taken as 75 per cent of the total deformation. Most of the remainder will be recovered in a few days. Deformation recovery where the load is applied at higher temperatures will have to be checked experimentally.

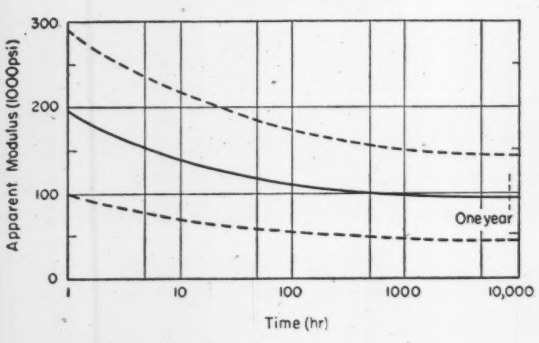
Stress Relaxation: Another consideration in the design of parts like gaskets and bolted assemblies is that cold flow will result in a lowered stress with time. This same problem is encountered with metals but not to the same degree.

For instance, a gasket of nylon resin might be bolted to an initial stress of 2000 psi on the gasket. In an hour this stress will be reduced to approximately 75 per cent of the original value because of cold flow and in 100 hr to 60 per cent. At the end of a year, the residual stress may be down to 40 per cent of the original value. Temperature changes will, of course, result in a more rapid relaxation of stress.

Several practical steps are available for gasket and similar problems. Confining the material, such as in grooves in a housing, will usually reduce the total motion that can take place.

Sealing pressure on gaskets can be maintained by starting with a higher unit pressure or by using a tightening system. A second load applied over the first reduces the rate of relaxation. Therefore, if a gasket were tightened again after one or more days of service it might not need further attention for months.

Fig. 5—Apparent modulus of elasticity as affected by time



Fatigue: Any material subjected to a varying load for a period of time will ultimately fail at a stress lower than the static strength. As the load is reduced it can be applied more times before failure occurs. The reversed stress (tension and compression) level where failure apparently will not occur is usually called the fatigue endurance limit.

Fatigue endurance data is given in *Table* 2. These data were determined at 1800 cycles per minute with the maximum tensile and compressive stresses equal.

Impact: Impact toughness, or the ability to absorb impact energy, is difficult to predict in a part because the shape has the major effect on performance. Understanding how a part resists an impact, however, will help in selecting a good design.

Energy of an impact has to be absorbed by a force developed in the part times a distance that the part can deform. Building flexibility into the part so that the distance factor becomes larger greatly reduces the force required to resist the impact.

Thus, thin-walled flexible pieces like coil forms or the open end of tumblers are almost indestructible by impact. On the other hand rigid corners supported in two or more directions or thicker sections may be less tough because they cannot deform enough to reduce the forces generated to a safe value.

Relative impact test results obtained for several commercial plastics as compared to Zytel 101 nylon resin are reported in *Table* 3. These tests were on specific shapes and may not be indicative of results obtained with other shapes. Of major importance is the difference in the relative toughness as measured by an actual end-use test compared to the Izod test.

Both Izod and unnotched impact values increase with increased moisture content. Parts in equilibrium with average air conditions will be twice as tough as those taken directly from the molding machine. It is important, therefore, that parts

exposed to impact loading be moisture conditioned after molding.

Wear or Abrasion: A resilient material like nylon may deform under load and return to its original dimensions without wear. While several commercial applications have demonstrated this ability, it is a property difficult to predict for any specific new use. Properties relating to the use of nylon as a bearing material are discussed in Part 2 of this series.

Taber abrasion tests showed that nylon loses from one-half to one-tenth the material that a number of other commercial plastics do under comparable test conditions. Ball-mill tumbling tests resulted in a weight loss less than one-tenth that of hard rubber, cast aluminum or mild steel. For these reasons, nylon makes a good lapping material for polishing dies, etc., because it will hold the abrasive and not wear away.

On the other hand, where a cutting action takes place, nylon will be shaved away rapidly, as would be expected since it machines easily. A sharp edge like a knife normal to the surface will make a mark but will not necessarily result in the removal of material. For instance, conveyor sections moving under stalled cans or glass bottles will be marked but no appreciable material will be removed from the surface.

The best procedure where performance cannot be predicted accurately is to test parts in the proposed application.

Chemical Attack: All the environmental changes so far discussed are reversible; that is, if a part containing moisture is carefully dried, its properties return to the original dry values. Conditions can be such, however, that the properties are permanently changed. The conditions most frequently encountered are long-time exposure at high temperatures to oxygen and water, or exposure to various chemicals.

OXIDATION: While Zytel 101 has a relatively high upper temperature limit for intermittent exposure, continuous long-time exposure to heat will result in oxidation and embrittlement of the outer surface in the presence of oxygen or air.

For longer service life, a heat-stabilized composition such as FE 2129 should be used for high-temperature exposure. An estimate of the expected service life at various temperatures for Zytel 101 and FE 2129 is given in *Table* 4. Otherwise, for design work, the properties of FE 2129 can be taken as the same as those for Zytel 101 except for impact resistance, which is reduced approximately one-half.

HYDROLYSIS: Neither fresh nor salt water has any appreciable chemical effect on nylon at temperatures below 100 F. At higher temperatures, water will slowly hydrolyze nylon until a lower molecular weight is reached. In time, an equilibrium is attained and no further change takes place.

For instance, boiling water exposure slowly reduces the tensile strength until at 2000 hr it is 6500 psi (tested at room temperature). The elongation drops rapidly after 1500 hr. For most applications a safe exposure time can be selected from the data in *Table* 5.

Molded objects will hydrolyze only on the surfaces exposed to the water. When the temperature varies, the time at elevated temperature must be estimated to get an idea of the actual change that

Table 2—Fatigue Endurance Limits

Moisture Level	Temperature (F)	Fatigue Strength (psi)
Dry	73	5000
Average air exposure	73	3000
Average air exposure	212	2000

Zytel 101 nylon resin.

Table 3—Relative Impacts Tests

Plastic	Izod Impact (ft-lb/in.)	Roller Test[1] (in.)	Repeated Impact[2] (in.)
Zytel 101 nylon resins[3]	2	35	30
Styrene-butadiene copolymer	2.3	3	2
Ethyl cellulose	2.8	9	5
Cellulose acetate butyrate	7	40	7
Styrene, butadiene and acrylonitrile terpolymer	7	8	3

[1]Roller, 0.7-in. OD by 0.35-in. ID, hit on outer surface by free-falling 2.7-lb weight. Height of fall required to cause a visible crack in one blow.
[2]Same roller test as in footnote 1, but height of fall necessary to cause failure in ten blows.
[3]Conditioned to 50 per cent relative humidity.

Table 4—High-Temperature Service

Temperature (F)	Service Life[1] Zytel 101 (hr)	Service Life[1] FE 2129 (hr)
170	1000	over 100,000
200	250	over 100,000
250	...	60,000
300	...	1500

[1]Under comparable end-use conditions.

Table 5—Service Life in Water

Water Temperature (F)	Exposure Time[1] (hr)
212	1 500
200	2 400
180	5 000
160	11 000
140	24 000

[1]Estimated life, Zytel 101 nylon.

will take place. It has been demonstrated that intermittent exposure is less severe than a single continuous exposure at the same temperature and the same total time.

CHEMICALS: Nylon resin is particularly resistant to alkalies and organic solvents. Apparently it is not affected by nor does it affect lubricating oils and greases. Nylon can be used with dilute acids but not with strong acids or oxidizing agents.

Formic acid and phenol are solvents for nylon. An aqueous phenol solution can be used as a cement for bonding nylon to itself.

Data for Zytel 101 after one month's exposure to various chemicals are given in *Table* 6. A change in properties occurred due to exposure to sulphuric acid. In all the other cases, the change was due only to the absorption of the liquid present—either water or a solvent—and not a chemical action.

In order to understand more clearly the effect of chemicals on nylon a solvent crack test was run on Zytel 101 with the chemicals listed in *Table* 7. A notch, 0.020-in. deep, was cut in a bar. The bar was then bent double with the notched side in tension and inserted in a test tube with the solvent to be tested. No cracking failures occurred in 30 days exposure at room temperature except for the sample in concentrated hydrochloric acid. At 170 F the samples in 5 per cent sulphuric acid and in lactic acid failed in 3 weeks. Also at 170 F, the bars in 5 per cent sodium hydroxide and ethylene glycol softened in 5 weeks. The other chemicals showed no effect.

Table 6—Effects of Chemicals and Solvents

Chemical or Solvent[1]	Weight Gain[2] (per cent)	Tensile Strength[2] (psi)	Cause of Change
Sulphuric acid			
3%	4.9	4 600	Chemical action
30%	7.0	4 300	Same
Sodium hydroxide			
1%	4.9	9 000	Change due to moisture
10%	3.1	8 100	pickup only
Ethanol			
50%	7.1	7 600	Same
95%	3.4	8 000	Same
Sodium chloride			
10%	3.7	10 000	Same
Ethyl acetate	0.1	10 100	Change due to material absorbed
Carbon tetrachloride	0.6	9 750	Same
Toluene	0.6	10 000	Same
Heptane	0.6	10 100	Same
Acetone	0.1	10 400	Same

[1]Immersion for 1 month.
[2]Zytel 101 nylon resin.

Table 7—Solvent Crack Tests on Nylon

No Effect[1]		Had an Effect[1]
Solvents Tested at 170 F		
1% Sodium hydroxide	50% Solution caprolactam	5% Sulphuric acid
Saturated sodium chloride	Acetamide	Lactic acid
Toluene	Nitrobenzene	5% Sodium hydroxide
Heptane	Ethyl propionate	Ethylene glycol
Mineral oil	Furfural	
Lubricating oil (SAE 20)	Dimethyl aniline	
Perclene	Oleic acid	
Butyl alcohol	Thiophene	
Butyl acetate	Castor oil	
Xylene	Cyclohexanol	
Chlorobenzene	Cyclohexanone	
Benzaldehyde	Cyclohexane	
Aniline	Hydrogenated vegetable oil	
5% benzene in SAE 20 oil	Ivory soap solution	
Dimethyl formamide	Acetic acid	
Solvents Tested at Room Temperature: All solvents listed above plus		
95% ethyl alcohol	Turpentine	Conc. hydrochloric acid
Carbon tetrachloride	Benzene	
Acetone	Bromine water	
Chloroform	2% Sodium sulfate	
Methyl phenyl ether		

[1]On Zytel 101 nylon resin

Outdoor Exposure: Certain nylon resins, such as Zytel 101, should not be used in applications exposed to direct sunlight for long periods of time. For such applications, a black composition, Zytel 105 BK10 is recommended. It has the same physical properties as Zytel 101 except for lower impact resistance, and it has excellent outdoor exposure resistance.

Design of Components: Part 2 of this series will discuss methods of dimensional control, and design of nylon gears and bearings. This final article will appear in the next issue of MACHINE DESIGN.

Anodizing Qualities of Aluminum

ANODIZING characteristics of various aluminum casting alloys are rated on lightness of color, brightness and uniformity. An evaluation of appearance of anodized finishes for aluminum appeared in MACHINE DESIGN, May, 1955, Page 227.

A revision announced by Reynolds Metals Co. brings these characteristics up to date. The accompanying table lists the revised appearance characteristics.

Anodizing Characteristics

Sand Casting Alloys		Permanent-Mold Casting Alloys		Die Casting Alloys	
Alloy	Rating (appearance)	Alloy	Rating (appearance)	Alloy	Rating (appearance)
12	Poor	43	Poor	13	Poor
43	Poor	A108	Poor	A13	Poor
108	Poor	113	Poor	43	Poor
112	Good	C113	Poor	85	Poor
113	Poor	122	Good	C214	Good
122	Good	A132	Poor	218	Excell.
142	V. Good	138	Poor	360	Poor
195	Good	A142	V. Good	A360	Poor
212	Good	B195	Fair	380	Poor
214	Excell.	A214	Excell.	A380	Poor
B214	Good	B214	Good	384	Poor
F214	Excell.	319	Poor		
220	Excell.	333	Poor		
319	Poor	355	Poor		
355	Poor	356	Poor		
356	Poor	382	Fair		

Introducing the Rational Plane

. . . a new graphical tool for finding Gear Ratios

By Arne Benson
Project Engineer Sanders Associates Inc. Nashua, N. H.

IN SELECTING a set of gears to satisfy certain kinematic requirements, the designer may employ one of several methods. If the restrictions (on the minimum or maximum number of teeth, their sum, difference, ratio, etc.) are not severe, he may refer to tables of decimal equivalents of fractions.

On the other hand, when the imposed conditions are such that these tables offer little economy of effort, two other methods are frequently employed. These are based upon the properties of conjugate fractions (Brocot series) or upon the properties of continued fractions and their convergents.

This article describes a "frame of reference" which provides a graphical method for the easier solution of ratio problems. Furthermore, it will demonstrate that the methods of continued fractions and conjugate fractions are two aspects of the same underlying mathematical reality.

The rational plane is a concept based upon point lattices which are known and used in the theory of numbers. A two-dimensional point lattice is a system of somewhat regularly spaced points arranged in a plane. Considered specifically here is that lattice which is composed of the points (x, y) in a rectangular co-ordinate system whose co-ordinates are positive integers. This particular lattice may be called the *rational plane,* a term coined for this specific application. The origin of the plane is the point (0,0). The mutually perpendicular lines passing through the origin will be called the n axis and the d axis.

In this plane *every line passing through the origin represents a unique real number and every lattice point a rational fraction.*

The uses to which the rational plane may be put in the solution of gear train problems becomes more apparent by recalling some of the properties of numbers and the symbolic systems by which these numbers are denoted. This background is briefly filled in by the accompanying discussion (*Some Properties of Numbers*).

Basic properties of the rational plane are formally detailed in the remainder of this article. How the rational plane can be used in the solution of gear problems is demonstrated by an accompanying series of examples.

A second article on this subject will show the useful complementary relationship of the rational plane to continued fraction convergents and conjugate fractions.

Some Properties of Numbers

A RATIONAL number can always be written as a ratio of integers and, conversely, every number expressible as the ratio of integers is a rational number.

When a number in the form n/d, where n and d are integers, the number is of fractional form.

When the number is expressed as a sum of integral multiples of successive powers of 10, the number is of decimal form. Thus 1/8 and 0.125 are fractional and decimal representations of the same number. These are by no means unique, since the same number is expressible in an infinity of ways as a fraction (1/8, 3/16, 3/24, . . . $t/8t$, . . .) and in one alternate way as a recurring decimal (0.1249999 . . .).

When n and d have no divisor in common, the

set of fractions tn/td (as t ranges through the positive integers) constitutes an equivalence class. Every fraction in the class is equal to the same rational number, and the class is commonly represented by its lowest member n/d.

A fraction, consisting as it does of two integers, represents a rational number exactly.

The decimal in principle also represents a rational number exactly, but unless the denominator d of its fractional equivalent consists only of powers of 2 and 5, (that is, $d = 2^{\alpha} \times 5^{\beta}$, for any nonnegative integers, α and β) the decimal does not terminate. In this case the decimal will, after some certain digit, consist of the same group of digits recurring endlessly.

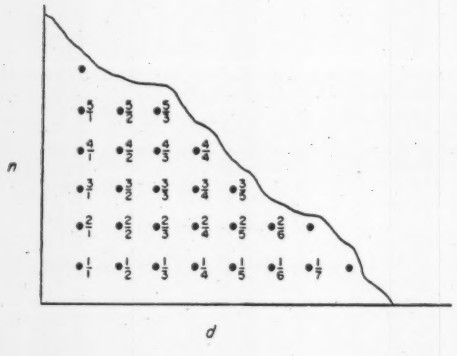
If a decimal terminates or recurs, it represents a rational number and, conversely, a rational number is expressible as a terminating or recurring decimal.

For practical computational purposes then, a decimal sometimes only approximates a rational number while a fraction is always exact. For example, for $3/7 = 0.4285142\ldots$, 0.4286 might be used and the error is $0.000028571428\ldots$

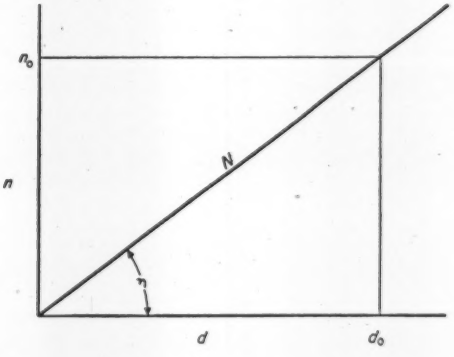
The decimal representation has the advantage that a set of numbers can readily be arranged in order of relative magnitude. There is no difficulty deciding which is larger: 0.692307 or 0.691489. Yet it would take a bit of computation to make the same evaluation of their fractional forms 9/13 and 65/94.

Irrational numbers, such as π, e, log 2, and tan 60 degrees, are not exactly representable in fractional form. In decimal form they always appear as an infinite sequence of digits with no recurrent period. Conversely, an infinite, nonrecurring decimal represents an irrational number.

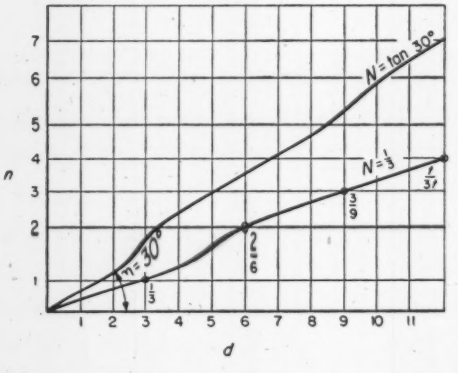
Properties of the Rational Plane



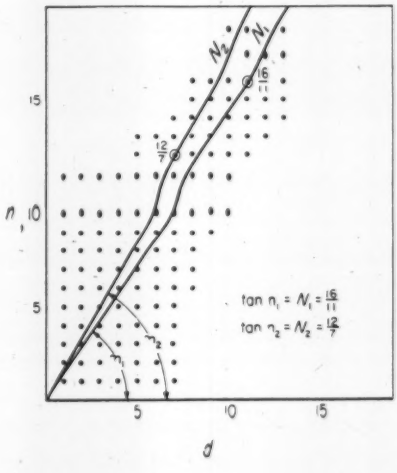
Property 1: Every fraction, n/d *is* represented once and only once in the plane by the point whose integral co-ordinates are n and d.



Property 4: The magnitude of the number is given by $\tan\eta$ where η is the angle formed by the d axis and its line, N.

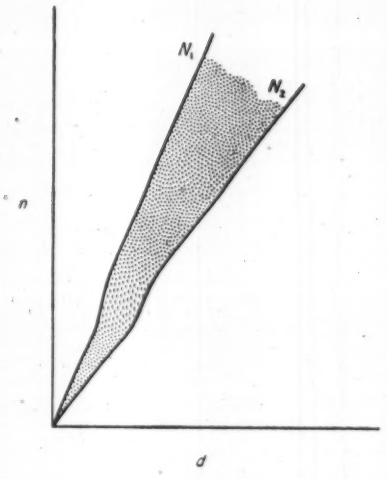


Property 2: A line drawn through the origin and the point n/d will contain all equivalent fractions tn/td ($t = 1,2,3,\ldots$) and no others. The point nearest the origin represents the fraction in lowest terms.

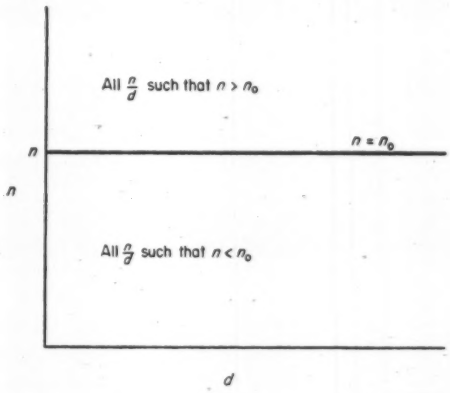


Property 3: Any positive real number may be represented by a line, N, through the origin. If rational, it contains the points of its class of equivalent fractional representations. If irrational, N passes through no other point than the origin.

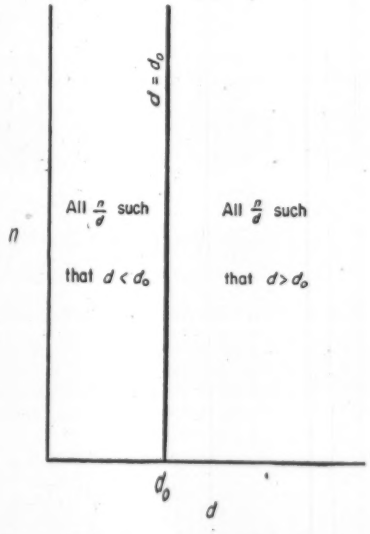
Property 5: Consider the ray anchored at the origin and lying on the d axis. As it is rotated through the plane in a counterclockwise direction it contacts the fractions (points) in order of increasing magnitude.



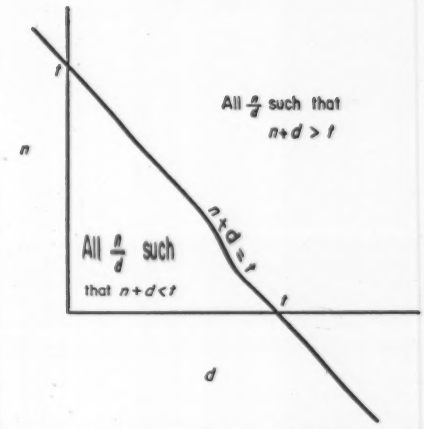
Property 6: The angular region between N_1 and N_2 contains all those fractions (n/d) whose value is between N_1 and N_2.



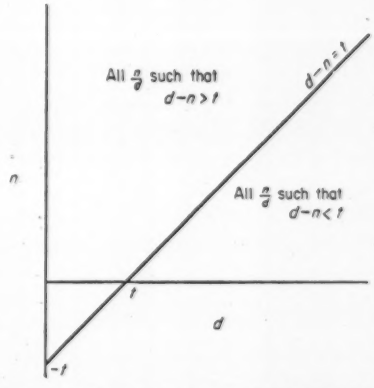
Property 7: The line $n = n_0$ divides the plane into two regions. The one above the line contains all fractions whose numerator exceeds n_0, while the region below it contains all fractions whose numerator is less than n_0. The line $n = n_0$ contains all fractions whose numerator equals n_0.



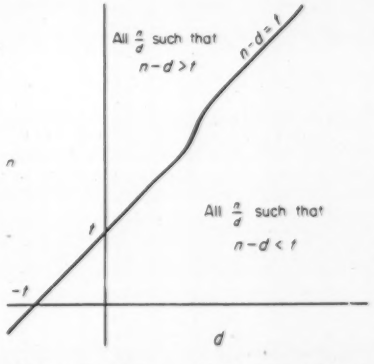
Property 8: The line $d = d_0$ divides the plane into regions which contain the fractions whose denominators are greater than, less than or equal to d_0.



Property 9: The line $n + d = t$ intersects the d axis and n axis both at t. It divides the plane into an inner triangular region and an outer infinite region. The inner region contains all fractions the sum of whose terms $(n + d)$ is less than t, while on the line lie all fractions such that $n + d = t$, and the outer region above the line contains those fractions the sum of whose terms exceed t.

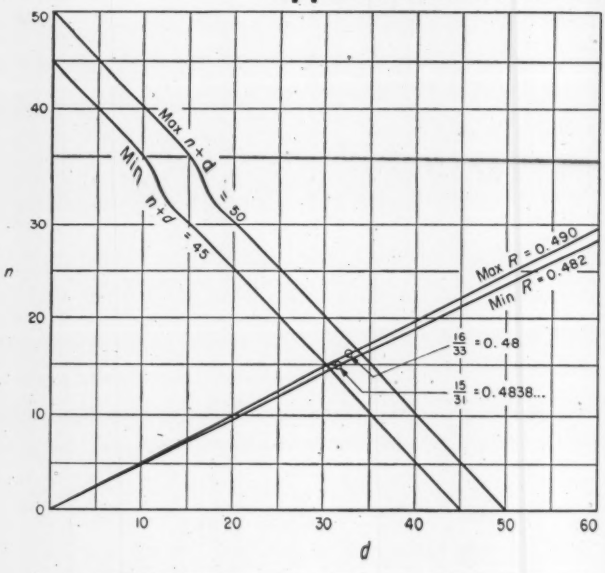


Property 10: The line $d - n = t$ intersects the d axis at $d = t$ and the n axis at $n = -t$. Below the line are all fractions less than 1 whose denominator and numerator differ by less than t. Above it are all those for whom this difference is greater than t, and on for line $d - n = t$ are all those fractions whose terms differ by exactly t.



Property 11: The line $n - d = t$ intersects t on the n axis and $-t$ on the d axis and divides the plane into regions which contain the fractions greater than 1 the difference of whose terms is greater than, less than or equal to t.

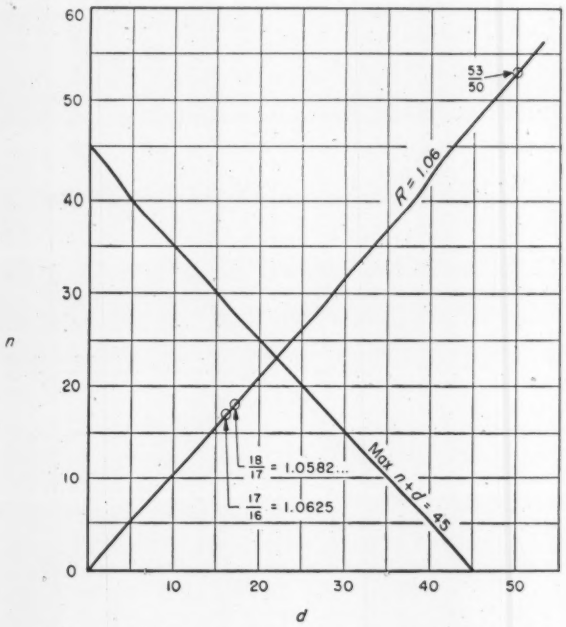
Applications of the Rational Plane



Example 1

Problem: The diametral pitch of a pair of gears is given, and available space dictates that their center distance must correspond to a tooth sum no greater than 50 and no less than 45. The ratio, R, shall be within the limits, $R = 0.486 \pm 0.004$.

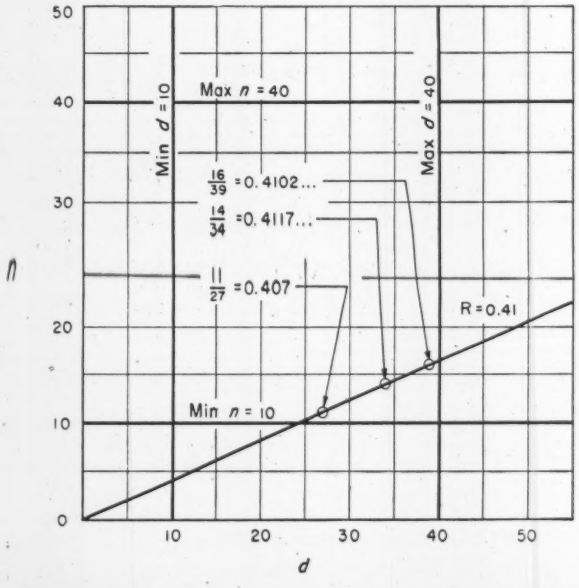
Solution: Draw the lines representing max $R = 0.490$ and min $R = 0.482$. All fractions intermediate in value lie within this triangular region. Draw the lines max $(n + d) = 50$ and min $(n + d) = 45$. The area enclosed by these four lines contains two points, 16/33 and 15/31. These are the only gear ratios satisfying the requirements of the problem.



Example 2

Problem: A pair of gears is required which will approximate the ratio, $R = 1.06$, each gear shall have more than 15 teeth and the tooth sum shall not exceed 45.

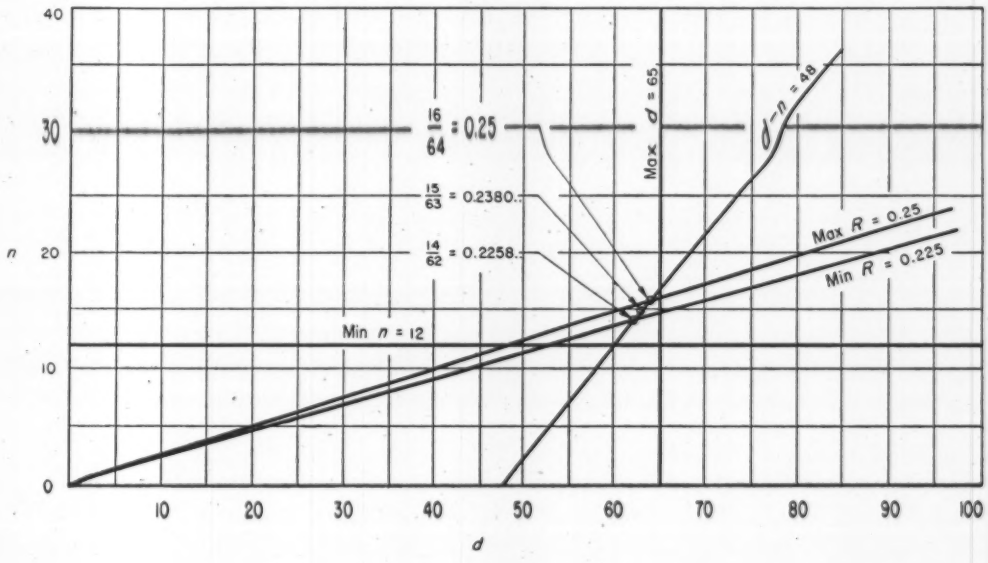
Solution: The points close to the line $R = 1.06$ within the region bounded by $d = 15$, $n = 15$ and lying on or below $n + d = 45$ represent possible gear ratios. The closest are seen to be 18/17 and 17/16. By a criterion which will be established later, 18/17 is the best approximation to 1.06 by any fraction whose denominator is less than 67.



Example 3

Problem: The given ratio is $R = 0.41$ and it is to be approximated with a pair of gears neither of which has more than 40 nor less than 10 teeth.

Solution: The points lying closest to the line $R = 0.41$ within or on the boundaries of the square region formed by $n = 10$, $n = 40$, $d = 10$, $d = 40$, represent approximations to the desired ratio. Three candidates are found: 16/39, 14/34, 11/27. Of these, 16/39 is the best ratio.



Example 4

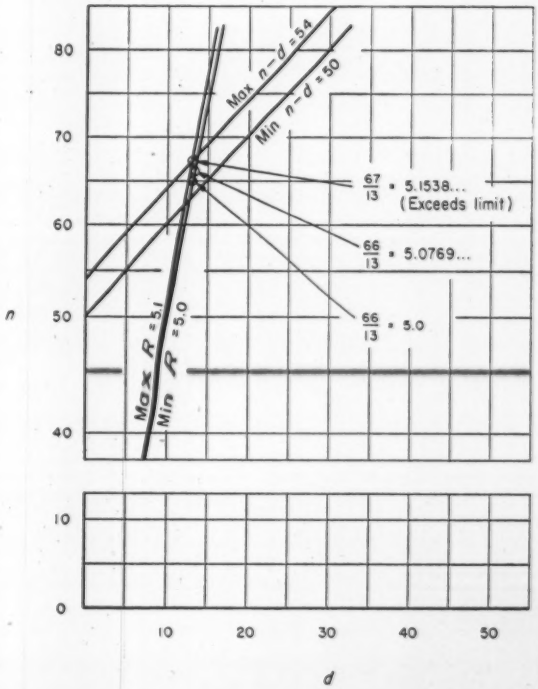
Problem: **The ratio of a pinion and an internal gear must be between max $R = 0.25$ and min $R = 0.225$. The center distance and the diametral pitch are known, and they dictate that the difference between the number of teeth of the internal gear and the pinion be 48, that is, $d - n = 48$. The pinion shall have no fewer than 12 teeth and the number of teeth in the internal gear shall not exceed 65. Find a suitable gear ratio.**

Solution: **As in *Example* 1, the solution will be found within or on the boundary of the region bounded by $R = 0.25$ and $R = 0.225$. The fact that the pinion must contain at least 12 teeth, further limits the region to that on or above $n = 12$. Similarly, the area to the right of $d = 65$ is excluded. Three fractions lie close enough to $d - n = 48$ to warrant attention: 16/64, 15/63, and 14/62. Each of these satisfies the requirements of the problem.**

Example 5

Problem: **The ratio, R, of an internal gear and pinion shall be not less than 5.0 nor greater than 5.1. Their difference, $n - d$, shall lie between the limits, 50 and 54.**

Solution: **As in the previous problem, the lines representing the limits on R and $n - d$ are drawn in the rational plane. Suitable ratios are found in or on the boundary of the region bounded by these four lines. Two solutions exist: 66/12 and 65/13.**



Points to consider in selecting

Hydraulic System Components

FUNDAMENTAL simplicity and great flexibility are two attributes of hydraulic systems that often permit a rapid first design approach to a given set of requirements. Selection of specific components is, in turn, greatly aided by the relatively voluminous data available on the characteristics of all kind of cylinders, pumps, valves, etc. Also, the advanced theory and techniques needed for special control situations are being increasingly covered in the literature.

But, design of the final system involves a host of choices based upon specific details. Often, selection of the best option is dependent upon practical knowledge of how best to apply hydraulic force and how to discriminate in actual situations among available component types and details.

To provide some help with these practical factors in design, this article briefly summarizes points to be considered in the translation of a system concept into a final design.

The sequence in which the final design is evolved can influence the effectiveness of the attack upon the problem. In general, selection of components in the order listed at the head of this article is perhaps the most logical.

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Cylinders and Motors: A variety of cylinder designs is available, *Fig.* 1. Cylinder size is dictated by load, operating cycle and maximum working pressure, regardless of design or type. Diameter and stroke of the cylinder should be selected to establish a working pressure that will give maximum over-all efficiency for the cycle of operation and keep heating of the system to a minimum. Generally, the lower the operating pressure, the less expensive the cylinder. Today, however, space and speed requirements generally favor small, high-pressure cylinders.

In most cases a small-diameter, long-stroke cylinder is preferable to one of large diameter and short stroke. The small-diameter unit will result in less shock and lower inertia loads because the ratio of cylinder stroke to work movement is lower, *Fig.* 2.

Inertia pressures are the impulse or surge pressures required to start or stop the oil and cylinder. Small oil lines or ports, poor cylinder construction resulting in high sliding friction, and low

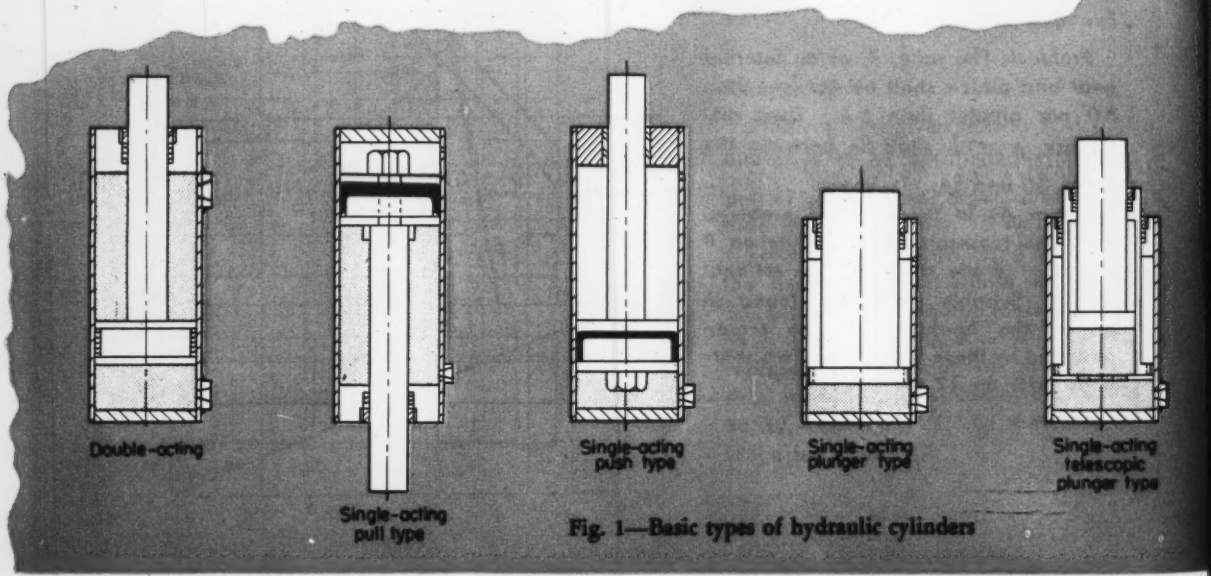

Fig. 1—Basic types of hydraulic cylinders

1—Cylinders and Motors
2—Pumps
3—Valves
4—Connecting Lines
5—Reservoirs
6—Accumulators

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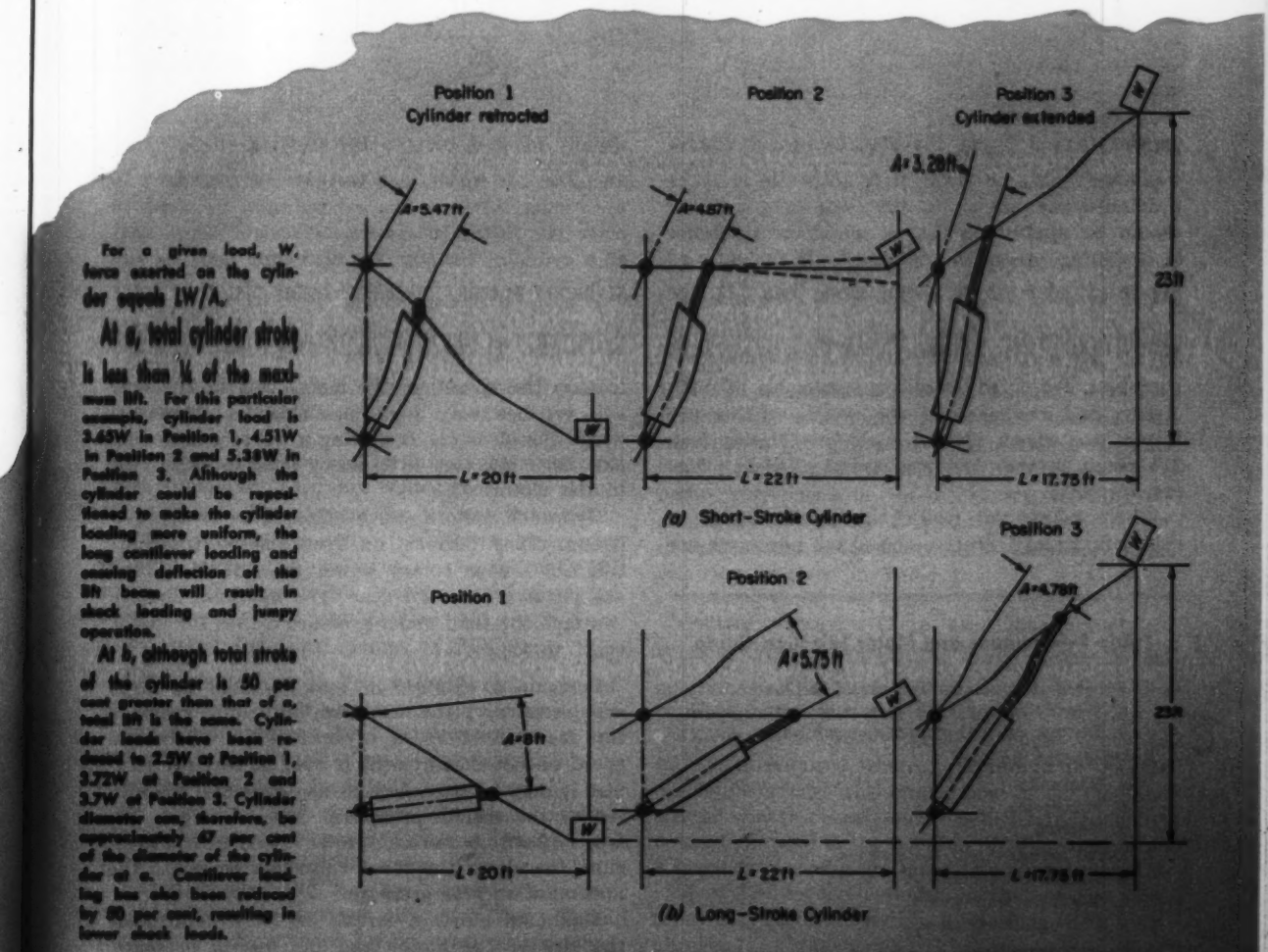
efficiency of the mechanism being operated all result in high inertia pressures. Shock pressures are those created by the load reacting against the cylinder. These pressures are caused by sudden stopping of the cylinder, traveling of a machine over rough floors or terrain, or any reaction that greatly increases the load momentarily. High inertia and shock pressures result in the system doing unnecessary work and are dissipated into the system in the form of heat.

A cylinder installation providing direct lift is the most efficient. However, because of space limitations, it is often desirable that the lift or movement of the load be greater than the cylinder stroke. When, for such a reason, the lift ratio or ratio of load movement to cylinder stroke is



For a given load, W, force exerted on the cylinder equals LW/A.

At a, total cylinder stroke is less than ¼ of the maximum lift. For this particular example, cylinder load is 3.65W in Position 1, 4.51W in Position 2 and 5.38W in Position 3. Although the cylinder could be repositioned to make the cylinder loading more uniform, the long cantilever loading and ensuing deflection of the lift beam will result in shock loading and jumpy operation.

At b, although total stroke of the cylinder is 50 per cent greater than that of a, total lift is the same. Cylinder loads have been reduced to 2.5W at Position 1, 3.72W at Position 2 and 3.7W at Position 3. Cylinder diameter can, therefore, be approximately 67 per cent of the diameter of the cylinder at a. Cantilever loading has also been reduced by 50 per cent, resulting in lower shock loads.

Fig. 2—Analyses of lift mechanism showing effect of cylinder stroke upon operation

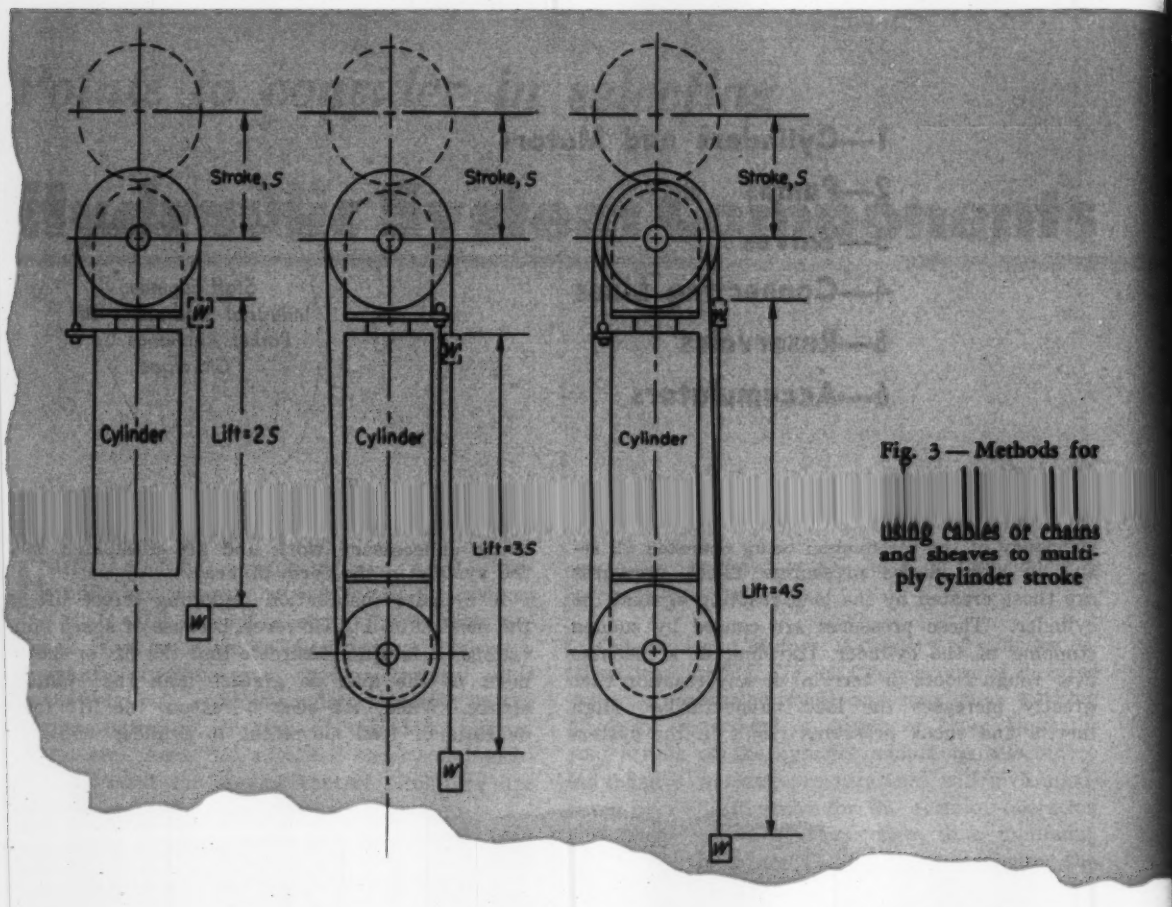


Fig. 3 — Methods for using cables or chains and sheaves to multiply cylinder stroke

greater than 2:1 and the load is on one end of a pivoted frame or beam, it is advisable to make a detailed analysis of the lift cycle. The cylinder should be applied so that a minimum difference in operating pressures will result. If the ratio of lift to cylinder stroke is not more than 2:1, the use of cables or chains reefed over pulleys or sprockets, *Fig.* 3, will result in reasonable lift efficiency, and resilience of the cables will reduce inertia and shock pressures. Ratios higher than 2:1 result in very low mechanical efficiency during operation.

Where rotary oil motors are used instead of cylinders, greater inertia and shock pressures are usually induced because the starting efficiency of an oil motor under load is very low compared to a cylinder. Hence, the oil pressure required to start the motor in motion is several times that of a cylinder. Usually, the oil motor must be run at higher speeds, producing faster piston or rotor movement. If the control valve is suddenly closed to stop the operation, the momentum of the load will produce very high shock loads. However, where the oil motor is driving a worm gear reduction assembly, very little shock pressure is carried to the motor.

Table 1—Cylinder and Motor Selection Guide

1. Force or torque requirement of the load
   a. When starting with maximum load
   b. During normal running conditions
2. Operating Speeds
   a. Minimum
   b. Maximum
   c. Normal
3. Drive arrangement for motors
   a. Direct connection
   b. Through spur gears
   c. Through worm gears
4. Service conditions
   a. Shock loading?
   b. No load starting?
   c. Continuous or intermittent operation?

Hydraulic motors can be classed as rotary cylinders. They perform an operation by transmitting continuous rotary power to a shaft. There are piston, vane, and gear type hydraulic motors in which the fluid under pressure causes the motor shaft to rotate.

Ports in a cylinder or motor should be large enough to carry the maximum oil volume required for the desired speed of operation. Where the speed of piston movement is over 60 feet per minute, it may be necessary to use oversized lines to reduce the inertia pressures. The lower the difference between working pressure and inertia pressure, the closer the relief valve can be set to the maximum working pressure.

Maximum starting torque or force determines the size of the motor and the inertia pressure. Maximum speed required multiplied by displacement per revolution of the motor or per inch of travel of the cylinder determines the pump output requirement.

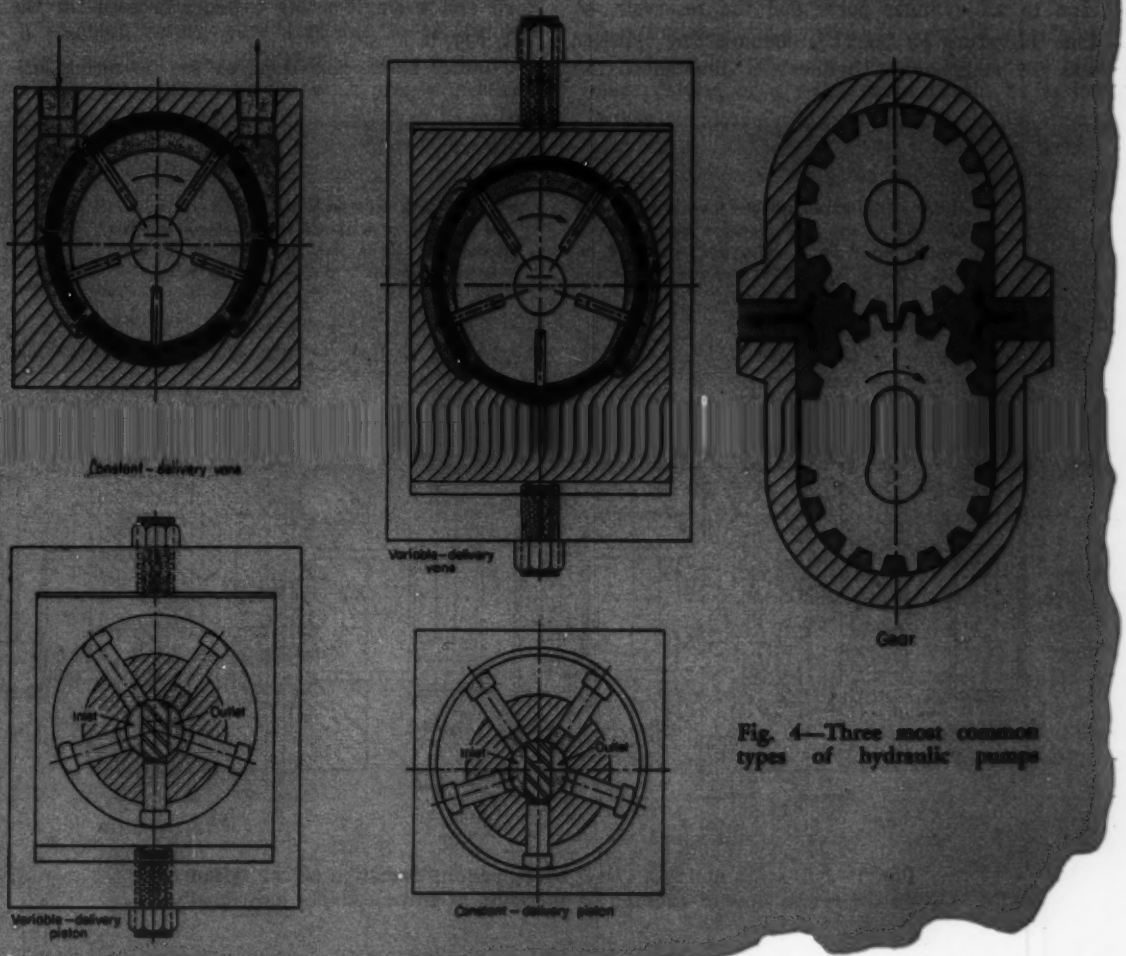


Fig. 4—Three most common types of hydraulic pumps

A check list of the requirements to be considered when choosing either a cylinder or rotary motor is presented in *Table* 1.

Hydraulic Oil Pumps: The three types of pumps most commonly used are vane, gear and piston types, *Fig.* 4. Vane types, *Fig.* 4*a,* may have either constant or variable delivery. Internal clearances of vane pumps may be fixed or controlled by oil pressure. Recommended working pressures for vane pumps range up to 1600 psi. Maximum operating speed for these pumps is 2500 rpm.

Gear pumps, *Fig.* 4*b,* are generally recommended for the more rough and ready applications. Internal clearances can be fixed throughout or oil pressure may be used to maintain constant clearance between gear faces and pump housing despite wear of their surfaces. Maximum operating pressures and speeds for gear pumps are about 2000 psi and 3600 rpm.

Piston pumps, *Fig.* 4*c,* may have either constant or variable delivery characteristics. These pumps are recommended for applications requiring working pressures in excess of 2500 psi.

A good rule-of-thumb to follow in determining pump horsepower requirements is that 0.7 horsepower is needed at the motor or engine drive shaft to deliver one gallon of oil at 1000 psi. Since 100 per cent efficiency would require only 0.58 horsepower, a mechanical efficiency loss of 0.12 horsepower per gallon of oil is anticipated. This clearly points out the advisability of selecting a pump very close in rated delivery to that required at the expected operating speeds. A list of conditions and requirements affecting pump selection is given in *Table* 2.

Control Valves: There are numerous styles, types, and designs of control valves. Some typical operations and the types of valves they require are detailed in the following paragraphs.

Full-series multiple valves or single valves in series are required where it is desired to operate one cylinder with the return flow of another and still be able to operate either cylinder individually. A good example is the hook-up of lift cylinders on a blade grader, *Fig.* 5. Since this circuit adds the load of the second cylinder to that of the first, there are, however, certain limitations to this application.

Series-parallel valves can be used for operating a double-acting cylinder and a single-acting cylinder at the same time. This valve feeds pressure to the cylinder ports from open center so

that only the valve upstream can feed oil to its cylinder. However, the return circuit is common to all cylinder ports and the reservoir, so that the return oil from the double-acting cylinder and the single-acting cylinder is directed to the reservoir. A good example is a lift-truck where double-acting cylinders are used for tilting the fork and a single-acting cylinder is used for the lift, *Fig.* 6.

Parallel valves are required for operating sev-

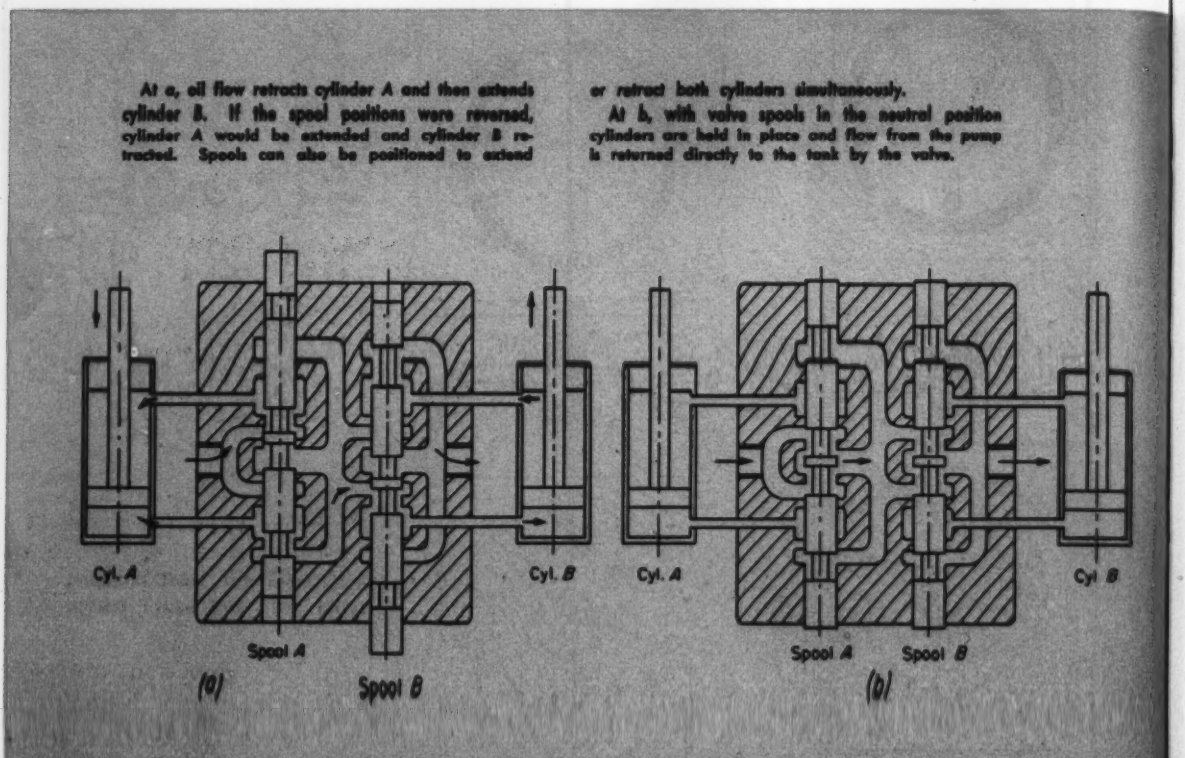

At a, oil flow retracts cylinder A and then extends cylinder B. If the spool positions were reversed, cylinder A would be extended and cylinder B retracted. Spools can also be positioned to extend or retract both cylinders simultaneously.
At b, with valve spools in the neutral position cylinders are held in place and flow from the pump is returned directly to the tank by the valve.
Cyl. A
Cyl. B
Spool A
Spool B
(a)
Cyl. A
Cyl. B
Spool A
Spool B
(b)

Fig. 5—Full-series multiple valve, which permits operation of one cylinder on the return flow of another, or operation of either cylinder individually

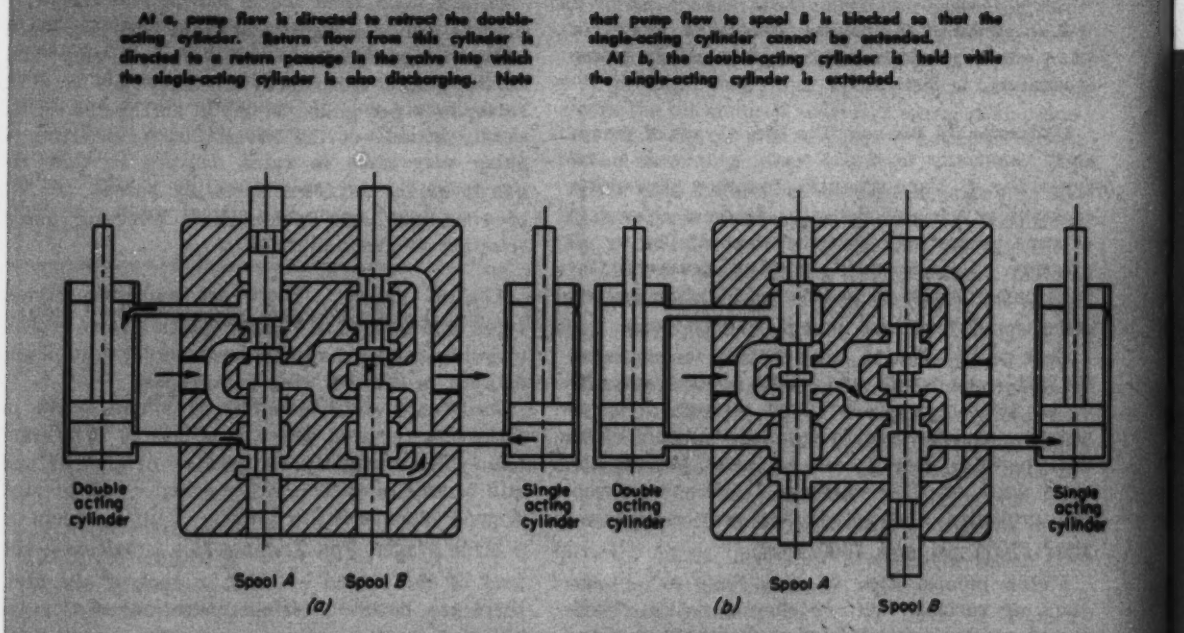

At a, pump flow is directed to retract the double-acting cylinder. Return flow from this cylinder is directed to a return passage in the valve into which the single-acting cylinder is also discharging. Note that pump flow to spool B is blocked so that the single-acting cylinder cannot be extended.
At b, the double-acting cylinder is held while the single-acting cylinder is extended.
Double acting cylinder
Single acting cylinder
Spool A
Spool B
(a)
Double acting cylinder
Single acting cylinder
Spool A
Spool B
(b)

Fig. 6—Series-parallel valve, which may be used to control a double-acting and a single-acting cylinder simultaneously

eral single or double-acting cylinders and for metering pump flow at different pressures to one or more cylinders at the same time. This valve has a common return port available to all cylinder ports and also a common high-pressure main available to all cylinder ports. With proper metering, it is possible to divide the pump flow to several cylinders at one time. The return flow from the cylinders to the reservoir is through to common return main, *Fig. 7*. This circuit is used on many loaders, lift trucks, etc.

Relief valves act as safety valves and relieve the system when the maximum pressure setting is reached. With certain modifications the return flow of a relief valve can be used to do another operation so that a sequence of operations is set up.

Difference in pressure between cracked and fully open position of a relief valve should be as low as possible. Relief valves, as well as certain others, may be obtained as integral parts of other valves. Use of such valve combinations is recommended to minimize piping.

Sequence valves, either pilot or mechanically operated, can be used to set up automatic sequencing of a series of operations.

Unloading valves can be used to direct pump flow to the reservoir at a very low pressure after relief pressure has been reached. These valves can also be used as relief valves or sequence valves. They can be manually reset to divert oil to the work or pilot reset by some pressure means.

Solenoid valves are positioned by solenoids, or sometimes in one direction by a spring and the other by a solenoid. These valves can be operated by a series of limit switches or timers to set up a series of successive operations. Solenoid-operated valves in control systems usually create less shock loading than manually or pilot-operated types. They may also be easier to apply because the switches controlling them may be located remote from the valve.

These brief discussions relate to the function of a particular type of valve. Selection of one type or another is usually influenced by circuit requirements. Certain general rules may also be applied to valve selection, regardless of the requirements of a particular circuit.

1. Valves must have ample capacity to provide minimum pressure drop through all ports.

Table 2—Pump Selection Guide

1. Pressure
   a. Maximum working
   b. Relief valve setting
2. Required oil volume
   a. At minimum pump speed
   b. At normal pump speed
   c. At maximum pump speed
3. Duty cycle
   a. Continuous operation
   b. Intermittent operation
   c. Continuous load
   d. Intermittent load
4. Prime mover
   a. Electric motor
   b. Internal combustion engine
5. Type of drive
   a. Direct coupling
   b. Belt or chain
   c. Gear

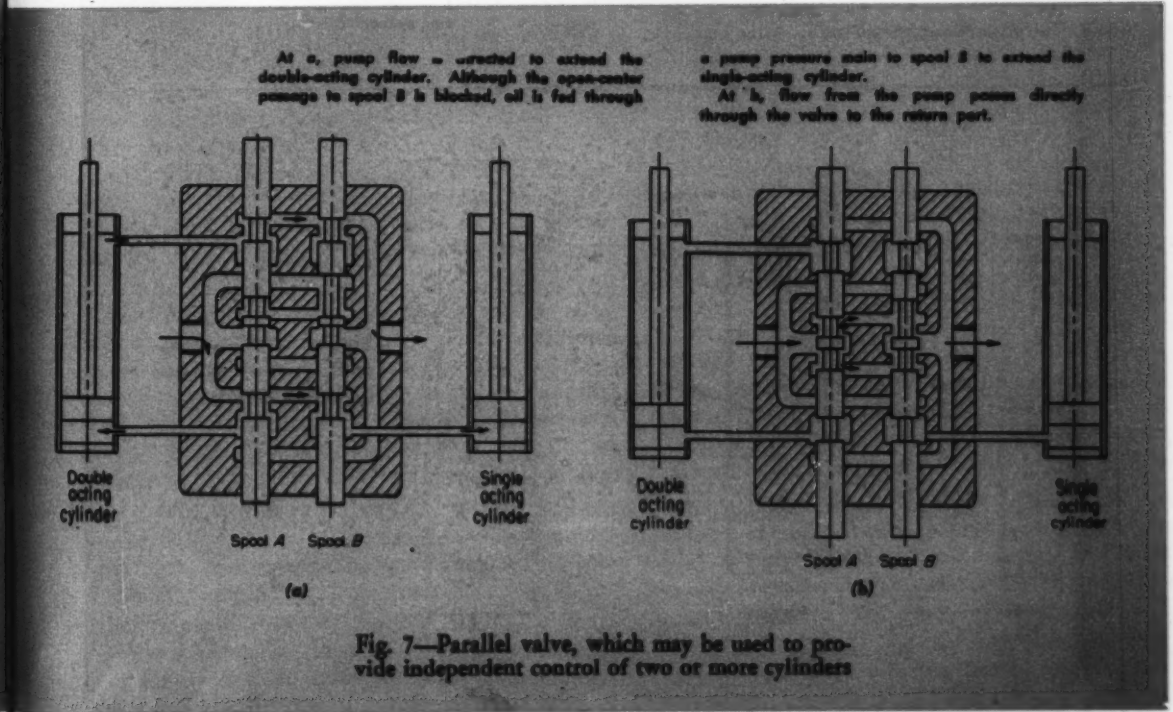

At a, pump flow is directed to extend the double-acting cylinder. Although the open-center passage to spool B is blocked, oil is fed through a pump pressure main to spool B to extend the single-acting cylinder.
At b, flow from the pump passes directly through the valve to the return port.
Double acting cylinder
Single acting cylinder
Spool A
Spool B
(a)
Double acting cylinder
Single acting cylinder
Spool A
Spool B
(b)

Fig. 7—Parallel valve, which may be used to provide independent control of two or more cylinders

2. Opening and closing of ports should not be too rapid or shock pressures will result. Valves having metering or throttling characteristics eliminate this problem.
3. Leakage in a spool valve depends upon the clearance areas subjected to pressure. Therefore, the smallest spool diameter which provides sufficient flow capacity should be used.

Oil Reservoirs: All reservoirs should be baffled to control the velocity of the oil after it enters the reservoir. Oil flowing at high velocity, if allowed to flow into the free air of the reservoir, will, by its agitation, collect air bubbles. Air bubbles cause the volume of oil in the system to increase, sometimes causing oil volume to exceed capacity of the reservoir and system. The bubbles burst when subjected to high pressures and in this process release undue heat into the system. Bubbles also deposit themselves as air in the components, especially the cylinders, causing sluggish and jumpy movement of the components during operation.

Velocity past the baffle should not be more than 4 fps and the velocity of flow into free air of the reservoir should be under 1 fps, *Fig.* 8. The outlet to the pump should be above the baffle so that the void caused by the rebound of the oil striking the bottom of the reservoir at high velocity will not affect the amount of oil going to the pump.

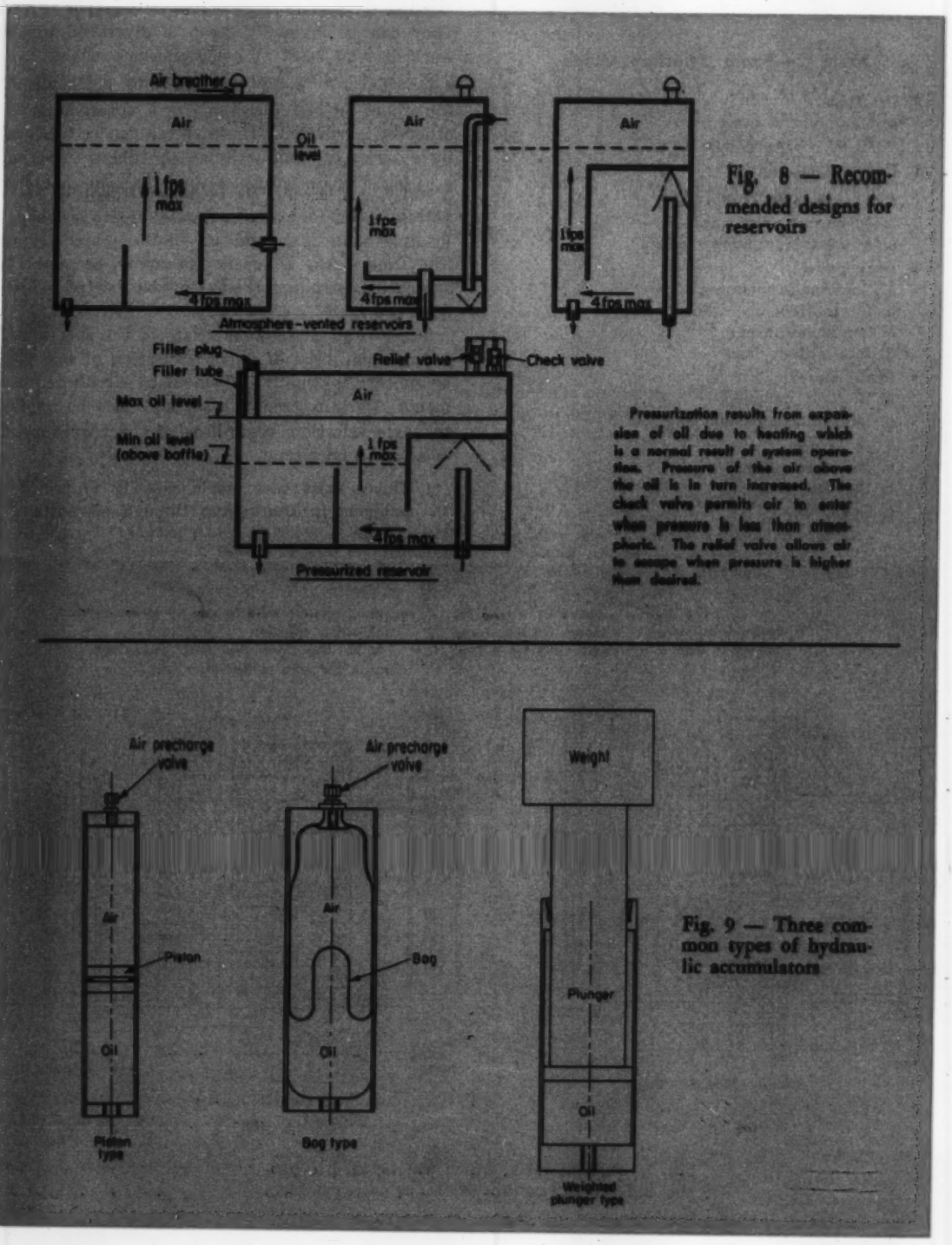


Fig. 8 — Recommended designs for reservoirs

Fig. 9 — Three common types of hydraulic accumulators

To keep vacuum at the pump inlet to a minimum and reduce the possibility of pump cavitation, reservoirs should be mounted above the pump when possible. The reservoir may also be pressurized to prevent cavitation, *Fig.* 8.

During operation of a hydraulic system, heat—the result of system inefficiency—is absorbed by the oil. This heat must be dissipated if the oil is to remain at a safe and efficient operating temperature. In some instances, a heat exchanger may be required to maintain the required temperature. But reservoir design and location may often eliminate this need. Surface area of the reservoir should be as large as is consistent with other requirements.

Reservoir capacity for mobile units is usually ½ gallon plus 10 per cent of pump volume plus total cylinder displacement, or rod displacement, in the case of double-acting cylinders. Air capacity equal to one-third of oil capacity should be allowed for expansion when the reservoir is vented to the atmosphere. When the reservoir is pressurized, air capacity of one-third oil capacity or twice cylinder capacity, if greater, should be allowed. These figures are based upon the fairly good cooling and usually intermittent operation typical of mobile systems.

For stationary systems, reservoir capacity should be 2 or 3 gallons per gallon of pump output, plus sufficient air capacity to allow for expansion of both oil and air when heated. Normal expansion of oil is 5 per cent per 100-degree F temperature rise. Air will expand approximately 21 per cent per 100-degree F temperature rise. This increase in reservoir capacity over that of the mobile system compensates to a certain extent for the inherently poorer cooling of the stationary system. However, heat exchangers will still be necessary in many instances.

Oil Lines and Oil Velocity: Selection of oil lines for a system is based upon velocity control and heat dissipation. Proper velocity keeps the pressure drop to a minimum and dissipates maximum heat. Metal lines dissipate more heat than other types and thus help in cooling the system. For this reason, hose should be used only to permit needed flexing during operation or to eliminate vibration.

Certain general recommendations can be made for velocities of oil through metal lines. The line from the reservoir to the pump should not have an oil velocity over 7 to 8 fps to prevent starving the pump. Velocity of all pressure lines, however, should not be less than 10 nor more than 17 fps. The return line velocity from the control valve to the reservoir also should not be less than 10 nor more than 17 fps. When single-acting cylinders are used, this return line must provide for both cylinder return flow and pump flow. It is not always possible to stay within these limits because of available standard pipe and tube sizes. Staying as close to these limits as possible, however, will help to insure a satisfactory system.

Restrictions in lines create pressure drops. These pressure drops or losses dissipate heat into the system at the rate of 25 Btu per gallon of oil at 1000 psi.

Accumulators: Oil under pressure discharged by the pump during the time that pump output is not required to do work in the system may be stored in an accumulator. This characteristic permits the accumulator and its output to be used in several ways. Certain uses for accumulators are as follows:

1. To store a large volume of oil under pressure using a small pump over a relatively long time period. This feature permits a reduction in pump size when high output for short periods of time is required.
2. To stabilize operating speeds by metering the flow through various devices. Thus, several operations may be performed at different speeds and pressures.
3. To permit full pump flow to be used for one operation while the accumulator flow is being used for others.
4. To operate one end of a double-acting cylinder in place of a spring. The hydraulic system will then operate the opposite end of the cylinder as a single-acting cylinder.
5. To act as a shock absorber to minimize the high-pressure impulses of the system.
6. To make up leakage in other components when positive clamping is required.

Accumulators may be bag, piston or weighted-piston types, *Fig.* 9. Each of these has certain characteristics which fit it to particular applications. Bag type accumulators are comparatively small and light, and can be mounted in any position. Piston type accumulators, either spring or compressed-gas loaded, are heavier than the bag types and may also be mounted in any position with no adverse effect upon performance of the accumulator.

Weighted-plunger accumulators are usually larger and heavier than other types. However, since gravity acting upon the weight atop the plunger is the energy source, these accumulators must be vertically mounted and are not used for mobile applications. Pressure is constant with this type of accumulator regardless of the amount of fluid used. This is not true of the other types where pressure decreases as the fluid is used to perform work in the system.

Unloading valves or pressure switches are used to start and stop the flow of oil to and from an accumulator and prevent the possibility of bottoming of the piston or bag. Accumulators are usually selected with twice the capacity required by the operation to be performed as an additional safety measure. The extra capacity also serves to reduce the pressure differential normally occurring as oil is used with bag and piston type accumulators.

Brazed Joints

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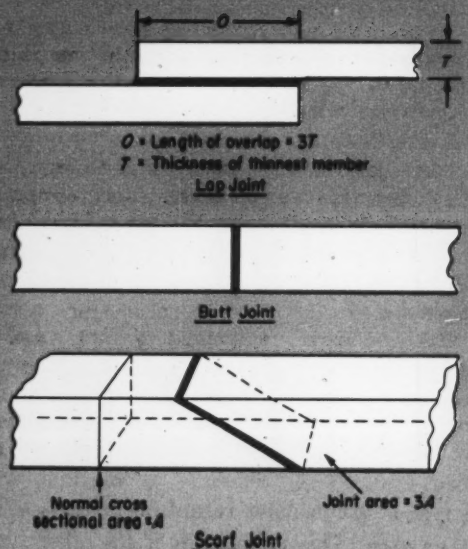


Fig. 1—Basic types of brazed joints are lap joint, butt joint and scarf joint. Lap joints provide high strength, leak tightness and good electrical conductivity. Butt joints are smooth and have good appearance but are weaker and have higher electrical resistance then the lap joint. Scarf joint combines good properties of both lap and butt joints but is more difficult to produce

BRAZING, while included under the general classification of welding, is a distinct metal joining process. Special consideration is necessary in planning the brazing procedure. One of the distinguishing features of brazing is the use of nonferrous filler metals having melting points lower than the metals joined. Thus, fusion between filler metal and base metal in the usual sense does not take place. In this respect, brazing is similar to braze welding. However, brazing differs from braze welding and the other welding processes in that it requires the use of much less filler metal if an effective joint is to result. Also, brazed joints are most successful when joints are subjected to shear.

Peculiarities of brazing make careful attention to a number of factors mandatory: selection of base and filler metals in accordance with job requirements; effective design of brazed joints; thorough prebraze cleaning of joint surfaces; careful assembly of joint members; thorough fluxing of joint surfaces; selecting the most suitable heating method; correct introduction of filler metal; and thorough post-braze cleaning are all instrumental in obtaining sound brazed joints.

However, this article will be limited to joint design, assembly of joint members, and heating methods since the problems involved are applicable

Design
Assembly
Heating Methods

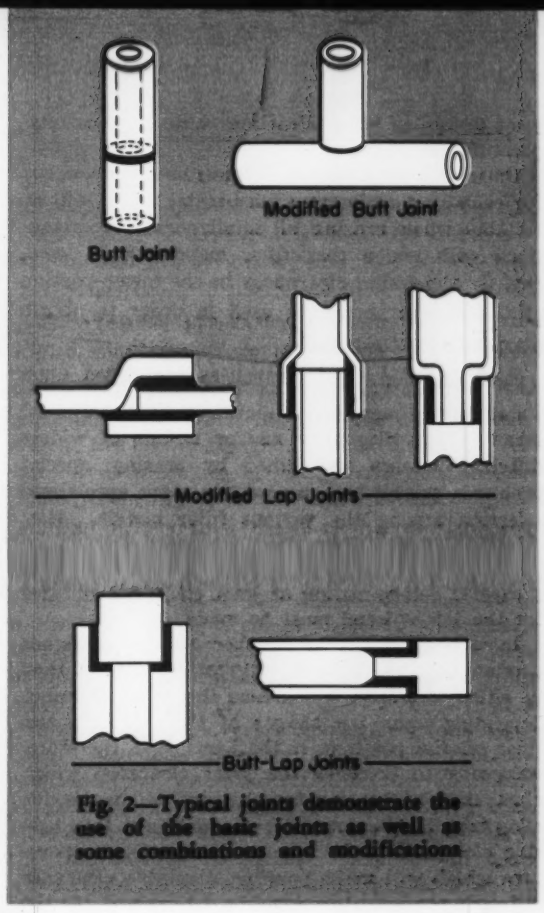


Fig. 2—Typical joints demonstrate the use of the basic joints as well as some combinations and modifications

in all brazing operations and, also, these considerations are likely to cause the most difficulty. Therefore, these procedures must be most carefully planned.

While design, assembly, and heating method each entails its own problems, there is one problem which they all have in common: preserving proper clearance in the joint. This might well be the most important factor in the production of sound brazed joints since, without proper joint clearances, there can be no capillary attraction which determines the distribution of a relatively very small amount of filler metal throughout the joint.

Design of Brazed Joints: In designing brazed joints, the first step is to make a proper selection of type of joint, keeping in mind the basic precept that brazed joints are most successfully used in applications subject to shear stress.

Butt and lap joints, *Fig.* 1, are the two fundamental types. The scarf joint is an intermediate type. It is identical with the butt joint at one extreme of the scarf angle and approaches the lap joint at the other extreme of scarf angle. Typical joint designs may combine the basic types, *Fig.* 2.

Selection of type of joint to use is influenced by the configuration of the parts as well as stress requirements and other service requirements such as electrical conductivity, pressure tightness, and appearance. Also influential in selecting joint type are fabrication techniques, production quantities, method of feeding filler metal, etc.

Lap joints are generally preferred for brazing operations, particularly where it is important that the joints be at least as strong as the weaker member, leak tightness is required, and good electrical conductivity is a factor. The lap joint length should equal three times the thickness of the thinner member joined for maximum strength.

Butt joints overcome the one inherent disadvantage of lap joints in that they provide a smooth joint of minimum thickness. Where smooth appearance is the prime consideration or where the double thickness of the lap joint would be otherwise objectionable, butt joints should be used. However, since the butt joint is difficult to fit-up so as to preserve the necessary joint clearances, its strength will not be as reliable as the lap joint, being particularly weak in bending. Furthermore, the electrical conductivity and leak tightness of a butt joint will not be as reliable as a lap joint.

A scarf joint is an attempt to achieve the smooth contours of the butt joint and the desirable properties afforded by the large joint area of a lap joint. However, to secure a lap of three times the thickness of the parts joined, it would be necessary to have a very small scarf angle. Machining a scarf, particularly on thin metal, would be a difficult and costly operation. Also, assembling the joint members to preserve the required joint clearances would be even more difficult. Scarf joint designs are, therefore, seldom used.

Reference has been made to joint clearance as probably the most significant factor in all of the brazing operations. Naturally, it receives special consideration when designing a joint. Joint clearance may be defined as the distance between the surfaces of the joint at room temperature, before brazing, into which the brazing filler metal will be flowed. Actually joint clearance is not the same at all phases of brazing operations. It is one value before brazing, another value at brazing temperature, and still another value after brazing, especially if there has been diffusion of the filler metal into the base metal. To avoid confusion, it has become general practice to specify clearance in the

joint design as being a certain value at room temperature before brazing.

Optimum clearance ranges have been worked out for each type of brazing filler metal which will be suitable when brazing all similar-metal combinations with which that filler metal can be used, *Fig.* 3. Generally, clearances in the lower portion of the ranges should be used in order to obtain maximum joint strength.

Recommended joint clearances are based upon joints having members of similar metals and equal mass. When dissimilar and/or metals of widely differing masses are joined by brazing, special problems arise which necessitate more specialized selection among the various filler metals. Also, a careful determination of joint clearance suitable for the job at hand must be made.

In such joints, the member with the higher thermal conductivity and/or greater mass will tend to either decrease or increase the joint clearance depending upon the shapes of the members and their relative positions in the joint. It is, therefore, necessary to consider the joint clearance which must exist at brazing temperature and make due allowance in the joint design to attain this useable clearance. Joint clearance at room temperature which will make possible a useable clearance at brazing temperature must be determined. At the same time, a brazing filler metal must be selected which will be useable over the brazing temperature range and the changing clearances which result. Thus, a filler metal with a long brazing temperature range is best for bridging relatively great gaps which may occur prior to or after attaining brazing temperature. On the other hand, a filler metal having a short brazing temperaperature range is preferred when joints are tight fitting through the room-temperature to brazing-temperature range.

The problem of stress imposed by joint loading should be anticipated and provided for in the joint design to minimize stress concentrations that may lead to tearing at the joint. Various joint designs, *Fig.* 4, may be used to solve stress problems by such means as increasing flexibility of that section of joint assembly where tearing is most likely to start, or stiffening of the more flexible parts. Each type of loading will have its own individual design problem with respect to stress minimization. When vibration or fatigue is a factor, the parts should be supported mechanically beyond both the brazed joint and the annealed area of the base metal.

The method of feeding filler metal into the joint must be kept in mind during the design stage so that allowances can be made for the effective

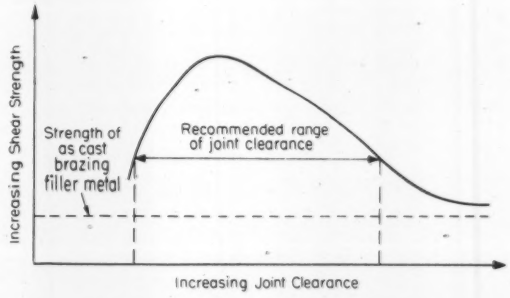
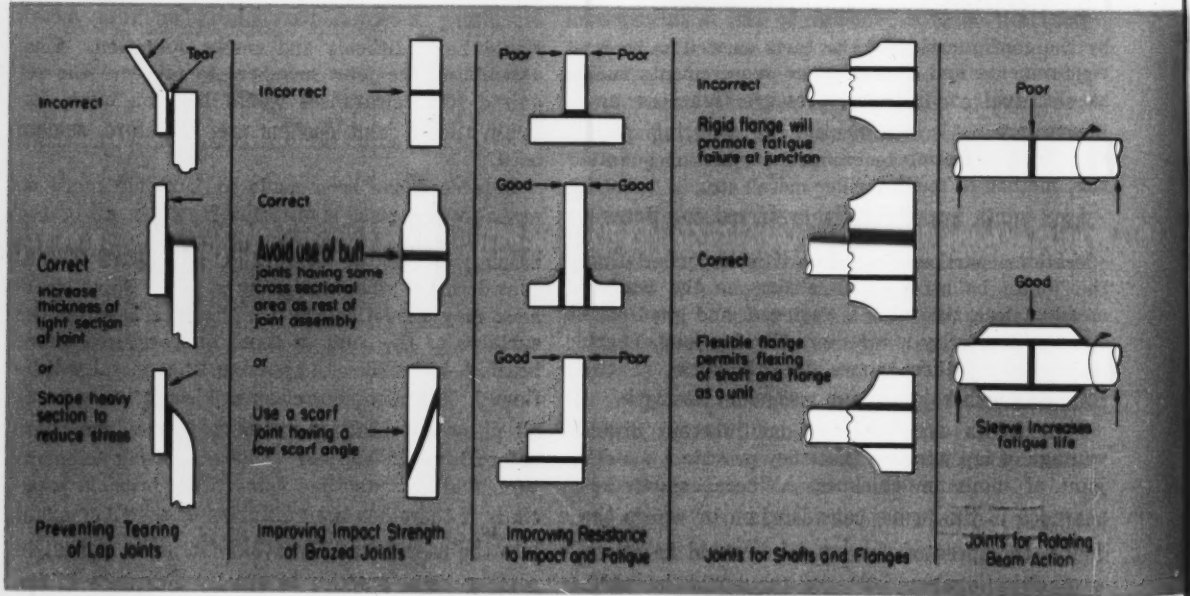

Increasing Shear Strength
Strength of as cast brazing filler metal
Recommended range of joint clearance
Increasing Joint Clearance

Fig. 3—Above—For each filler metal there is an optimum joint clearance range. Values below the minimum will give low strength because filler metal flow is obstructed. Clearances larger than optimum require excessive quantities of filler metal and may result in loss of effective distribution of filler metal because capillary action is destroyed

Fig. 4—Below—Correct design of brazed joints reduces stress concentrations and, therefore, the possibility of tearing, fatigue failures and failure under impact loading



introduction of filler metal into the joint and its subsequent flow throughout the joint. Filler metal is either face fed or preplaced in, or adjacent to, the joint. When the filler metal is face fed, it is hand held and applied to the face of the heated joint just as brazing temperature is reached. Therefore, the joint must be of an exposed design to permit operator access to the joint face.

When the filler metal is preplaced the joint face may be either exposed or concealed, *Fig.* 5.

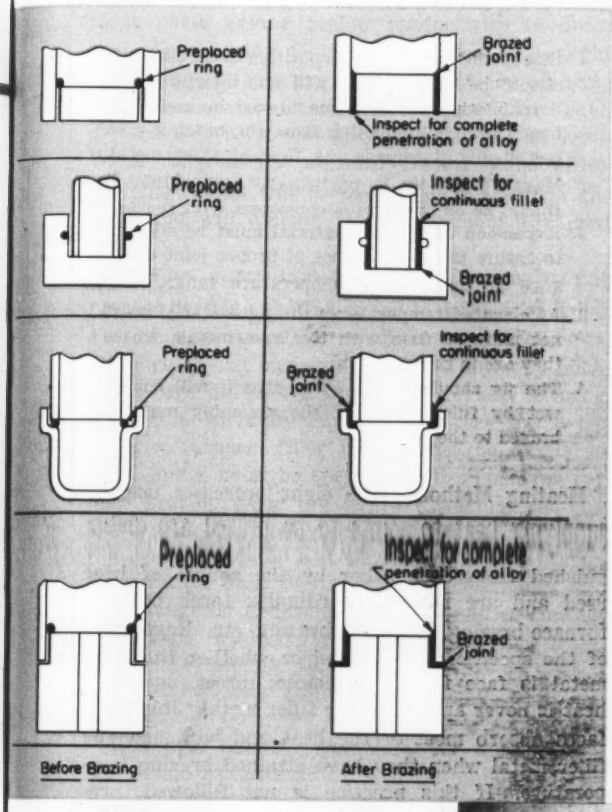


Fig. 5—Above—When filler metal is preplaced, the face of a brazed joint may be either exposed or concealed. However, it is desirable to design the joint so that it can be inspected for complete filling after brazing. Placement of filler metal so that flow will be aided by gravity is desirable

In designing joints for preplaced filler metal, the joint should be arranged so that the metal flow will be assisted by gravity and so that the joint can be inspected to insure complete filling of the joint. Various preplacement filler metal forms, *Fig.* 6, may be used for preplacement. The filler metal may be placed at the extremities of the joint or it may be inserted in a groove in the joint, *Fig.* 7, the groove being in the heavier joint member. Area taken up by the groove must be deducted from the effective joint area since it will not contain any filler metal at the completion of brazing operations. If flat washers or shims, *Fig.* 8, are used as preplacement forms, it is necessary to provide for application of pressure to the joint or other means of assuring proper flow of filler metal.

Brazed joints are very effective for joining electrical conductors. However, it is obvious that the joint must not alter the resistance of the circuit appreciably. In joining copper conductors, tests have shown that a lap of one and one-half times the thickness of the thinner member will have a resistance the same as an equal length of copper conductor. Of course, if a longer lap is needed to satisfy strength requirements, this will also be satisfactory electrically and shows even lower resistance.

If several joints are to be used in fairly close proximity on the same assembly, the joint design should specify step brazing. This is a technique which permits making several brazes in sequence without disturbing joints previously made. To accomplish this end, joint design should specify the use of several filler metals which exhibit dif-

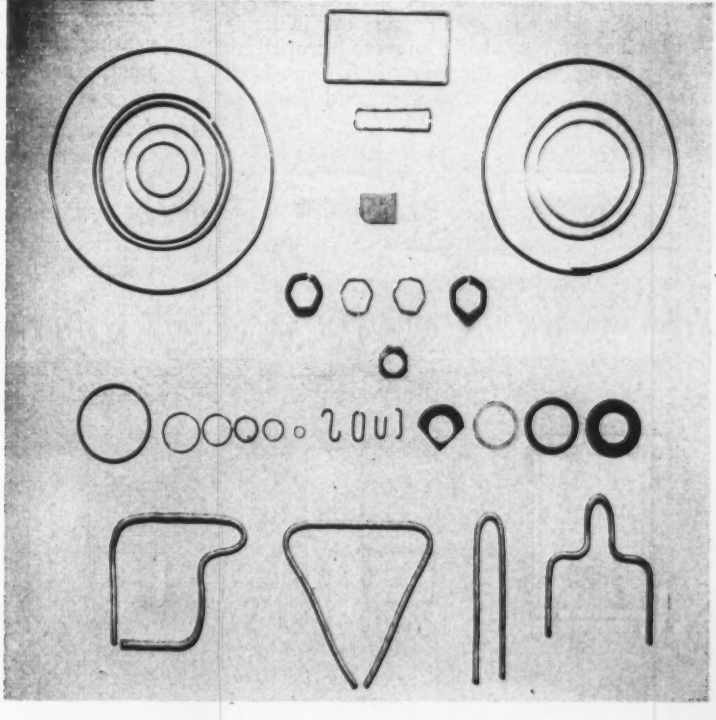


Fig. 6—Right—Filler metal may be formed in a variety of shapes and sizes for preplacement

ferent brazing temperature ranges. Thus, the first joint can be made with the filler metal having the highest temperature range, the second joint with the next highest temperature range, etc.

The use of brazed joints in pressure-tight assemblies requires, as already mentioned, a lap type joint, and also provision must be made for proper venting of heated gases formed during brazing, *Fig.* 9. If this is not done, the expansion of the hot gases within an assembly is likely to force the assembly apart or expel the molten filler metal from the joint.

Assembly of Joints: Joint assembly should be anticipated during joint design. Often it is possible to design joints so that they are self-jigging, *Fig.* 10. However, with some joints it is necessary to use jigs in the form of clamps and supports, and with the use of jigs certain problems arise, some having to do with the jigs alone and some related to the use of jigs, when using particular heating methods.

Decision as to how to assemble joint members is predicated on the fundamental requirement that the simplest assembly method capable of securely holding the joint members in correct alignment and maintaining clearance during the heating and cooling cycle of the brazing operation is always preferable.

If jigs are used they must fulfill the following general requirements:

1. Size of the jig and the disposition of its elements should be such that it will not interfere with even heating of the parts brazed by removing heat through conduction from the brazing area nor should it impede the flow of filler metal. Mass of the jig is particularly important. It should be as small as is consistent with the job.
2. Expansion of the jig material must be such as to assure the maintenance of proper joint clearance at the brazing temperature range.
3. At elevated temperatures the jig material must not alloy or fuse with the base metals where they are in contact.
4. The jig should be set up so that it will not be wet by filler metal or the assembly may be brazed to the jig.

Heating Methods: The eight processes used in supplying heat to joints to be brazed are distinguished from each other by the source of heat used and are named accordingly: torch brazing, furnace brazing, induction brazing, etc. Regardless of the specific method used or whether the filler metal is face fed or preplaced, direct, sustained heat is never applied to the filler metal. Joint surfaces absorb most of the heat and will melt the filler metal when they have attained brazing temperature. If this practice is not followed, premature melting of filler metal may occur, preventing the desired capillary flow throughout the joint, since this flow largely depends on the joint being at the proper temperature.

In all brazing methods, the joint must be brought to brazing temperature as rapidly as possible. However, overheating of local areas must be avoided as much as general under-heating, since these practices may induce thermal stresses and distortion to destroy joint clearance and cause other

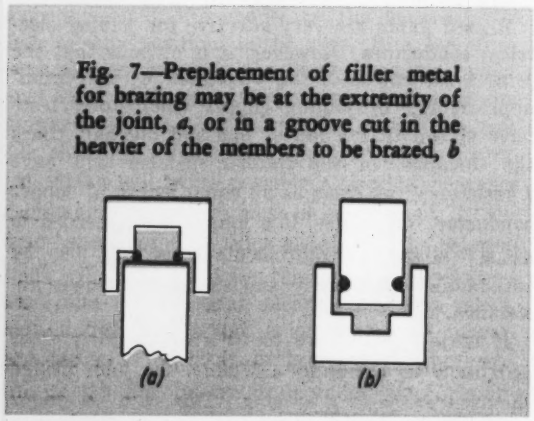


Fig. 7—Preplacement of filler metal for brazing may be at the extremity of the joint, *a*, or in a groove cut in the heavier of the members to be brazed, *b*

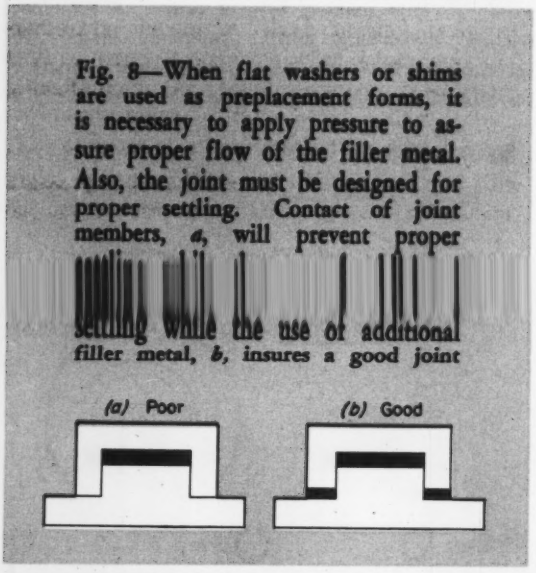


Fig. 8—When flat washers or shims are used as preplacement forms, it is necessary to apply pressure to assure proper flow of the filler metal. Also, the joint must be designed for proper settling. Contact of joint members, *a*, will prevent proper settling while the use of additional filler metal, *b*, insures a good joint

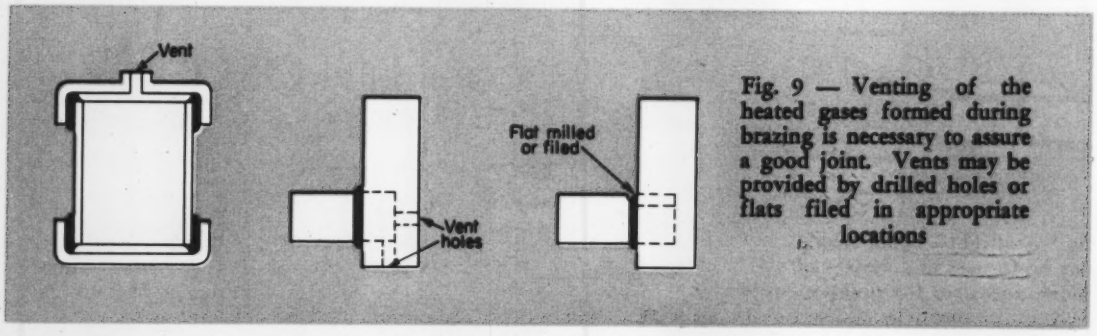


Fig. 9 — Venting of the heated gases formed during brazing is necessary to assure a good joint. Vents may be provided by drilled holes or flats filed in appropriate locations

unwanted reactions.

Each brazing method has its own peculiar advantages depending on the particular brazing job involved and should be selected accordingly.

Torch brazing, while normally thought of as being done with the oxyacetylene torch, also can employ air-acetylene torches as well as other fuel gases burned with air or oxygen. Manual torch brazing requires skill on the part of the operator, particularly in the application and distribution of heat. The assembly to be brazed is first heated generally to raise its temperature. In doing this, more heat is directed to the heavier masses or those parts having higher conductivity in order that the opposing joint surfaces may be brought to brazing temperature at the same time. Heating is continued and at the same time the filler metal, if face fed, is occasionally touched to the joint. When the joint has attained brazing temperature, the filler metal will be melted by the heat of the joint and will quickly flow throughout the joint area.

Furnace brazing is a high-production brazing process particularly well suited to assemblies which are of approximately equal masses. Joint assemblies having elements of widely different thicknesses are difficult to handle in furnace brazing. Since it is virtually impossible to face feed when using a furnace, filler metal must be preplaced. Also, joints must be specifically designed for furnace brazing since the entire assembly, not just the joint surfaces, will be raised to the brazing temperature and, therefore, joint clearances may be endangered if dissimilar metals and/or unequal masses are involved. When preplacing filler metal, in furnace brazing, filler metal should be next to the heavier joint member to prevent premature melting.

Whenever possible, assemblies for furnace brazing should be designed to be self-aligning and self-jigging. Any jig structures introduced into the furnace must be heated to the brazing temperature and this may result in slower overall heating and increased costs. Springs must not be used in the jig design because of the loss of tension when heated. Instead, systems involving cams or weights are used extensively for maintaining proper pressure on parts during heating and subsequent cooling to room temperature.

Induction brazing is a high-production process in which localized heat is induced in the joint area. Alternating current of high frequency is fed into a work coil which surrounds the work piece at the joint area. This high frequency induces an eddy current in the joint, and this current provides the heat for brazing. By careful design of the work coil and selection of frequency, heat can be localized in the joint area. This feature, coupled with rapid heating which reduces the time during which the parts are subjected to high temperatures, may be advantageous with some metals and assemblies. Localized joint heating can be helpful, for example, in maintaining proper joint clearance with dissimilar and/or metals of differing masses. Filler metal is preplaced.

Resistance brazing is another electrical heating process. In this instance, the heat is obtained from resistance to the flow of an electric current through the electrodes and the joint to be brazed. Thus, the parts comprising the joint form part of the electric circuit. This method is most suitable for joints of comparatively small areas, since uniform current distribution and uniform heating is difficult to obtain with large or irregular joint areas. The joint must also permit application of pressure to both sides without distortion. Further, it is preferable to have the work pieces self-aligning, thus eliminating jigs and fixtures.

In applying current, the parts to be brazed are held between two electrodes at proper pressure. This pressure is maintained after filler metal has

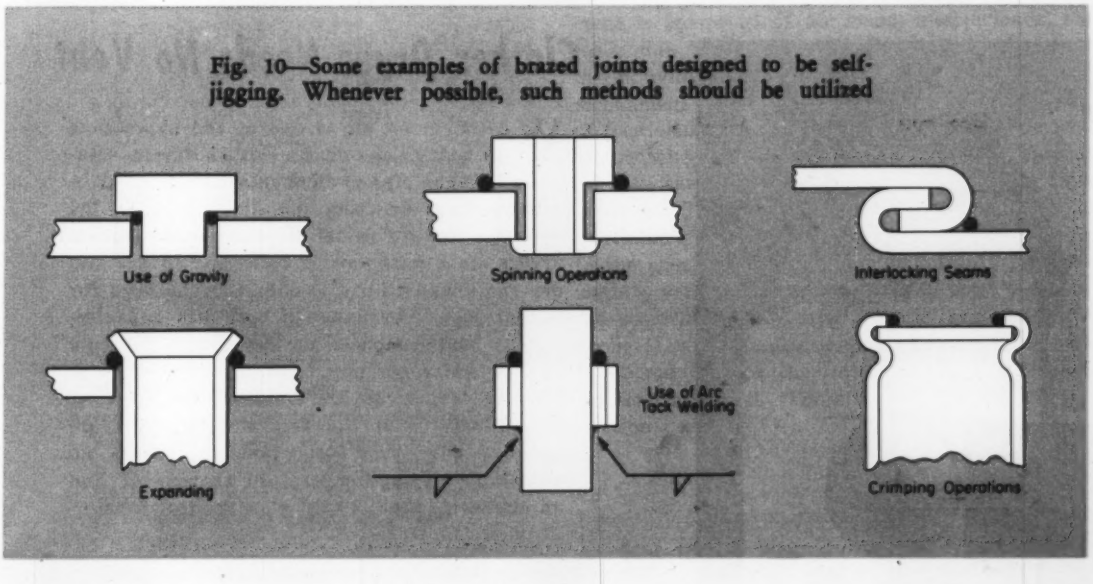


Fig. 10—Some examples of brazed joints designed to be self-jigging. Whenever possible, such methods should be utilized

flowed and is not removed until the joint has solidified. For some work, both electrodes may be located on one side of the joint while a suitable backing to maintain the required pressure is applied at the other side. The filler metal may be either preplaced in the joint or face fed.

Dip brazing derives the necessary brazing heat from molten baths—either molten filler metal or molten flux. Therefore, this method is further identified as being either molten metal dip brazing or molten chemical bath dip brazing. Molten metal dip brazing is necessarily limited to small assemblies since immersion must not lower the temperature of the bath below brazing temperature. Also critical in maintaining brazing temperature is the size of the bath crucible and the method of heating the crucible. Molten chemical bath dip brazing, on the other hand, can be used with assemblies weighing several hundred pounds.

With molten metal dip brazing, the joint assembly must be cleaned and protected with flux before being immersed in the metal bath. Jigs naturally cannot be used and, therefore, self-jigging of the parts is necessary.

With molten chemical bath dip brazing the parts are cleaned and the filler metal preplaced before immersion. Jigs may be used or the parts may be self-jigged to hold together the assembly and maintain proper joint clearance.

Summary: Successful brazed joints largely depend upon the degree of planning in designing joints, assembling joint members, and selecting a suitable heating method for the particular job involved. In review, then, the following points are necessarily emphasized in planning brazing operations:

1. Preservation of proper joint clearance is probably the most important factor in obtaining sound brazed joints.

2. The brazed joint is most successful in applications subject to shear.

3. The lap type joint is preferred over butt and scarf joints in giving desirable physical and electrical properties along with the greatest ease of production.

4. Each filler metal has an optimum recommended range of clearance which applies when it is used in joining similar metals and metals having equal mass.

5. When brazing dissimilar metals and/or metals of unequal mass, special consideration must be given to selection of filler metal and determination of joint clearance.

6. Joint design should minimize stress at the joint.

7. Joint design should specify method of feeding filler metal into the joint.

8. If several joints are to be used in fairly close proximity on the same assembly, the joint design should specify step brazing.

9. Provision must be set forth in joint design for venting joints in pressure-tight assemblies to permit escape of hot gases generated during brazing.

10. Whenever possible, assemblies to be brazed should be self-jigging.

11. Each heating method has its own requirements and advantages. Regardless of heating method and whether filler metal is face fed or preplaced, only the joint surfaces, not the filler metal, receive direct, sustained heat with brazing temperature in the joint being attained as rapidly as possible.

Contemporary Design

Clothes Dryer Needs No Vent

WARM, moist air is one of the byproducts of today's automatic clothes dryers. Generally, a vent pipe or duct must be installed to exhaust this air from the dryer area to the outdoors. Latest model Maytag no-vent clothes dryers use a water-cooled condenser to cool and dry the exhaust air and eliminate the need for a vent pipe. Available in both gas and electrically heated models, the dryer uses 2.7 pints of cold water per minute of operating time to cool the exhaust air and condense the moisture. Other features of the new Maytag dryer are an adjustable timer for periods to 2 hours, an adjustable drying-temperature thermostat and an attractive back-lighted glass control panel.

How force requirements and design for strength are influenced by

Friction in Mechanisms

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IN THE LOAD analysis of mechanisms with rotating link members the effects of frictional forces are often difficult to evaluate. Members can be joined with bolts, bolts and plain bearings, or bolts and antifriction bearings. Friction may be helpful or detrimental to the design, depending on the function being considered. The following examples provide methods of approach for three representative cases.

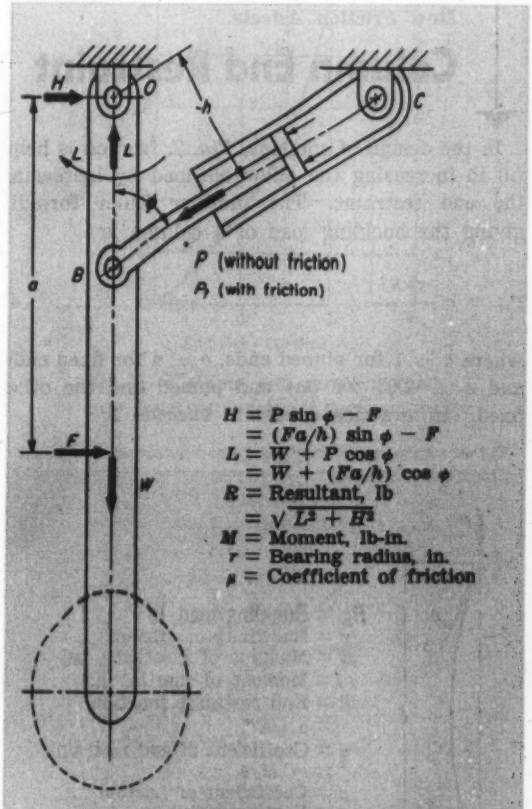

Fig. 1—Airplane landing gear, representative of mechanisms requiring added force input to overcome friction. Fluid pressure in cylinder retracts wheel against weight *W*, drag *F* and friction at links *O*, *B* and *C*

How Friction Affects

Force Input

The linkage illustrated in *Fig.* 1 represents an airplane landing gear subsequent to take-off. The design requirements for this condition are (1) the actuating cylinder must be designed to overcome the peak retraction load, and (2) the hydraulic system must supply sufficient fluid rate of flow to the retraction cylinder so that the time of retraction will not exceed a given maximum. The load which the hydraulic cylinder must overcome is composed of air loads, inertia loads, and loads due to friction. Friction loads occur both in the cylinder itself and in the joints of the gear mechanism. The cylinder force required because of frictional resistance in the joints will be derived.

The wheel is rotated from its down position up into the airplane by rotation about the fixed pivot *O*. The external force is supplied by the hydraulic cylinder fixed at pivot *C* and attached to the shock strut at *B*. As the rotation proceeds, angle ϕ varies. Retraction force P_t must overcome the moment due to drag force *F* and weight *W* about *O*, and the friction moments in the joints *O*, *B* and *C*. For the initial position, *W* has no moment about *O*. Therefore, neglecting bearing friction,

$$P_o = \frac{Fa}{h} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

At joint *O*, the resultant load on the bearing is

shown in *Fig.* 1. The friction moment at O is

$$M = R\,\mu_O\,r_O$$

The increment of load in the hydraulic cylinder necessary to overcome this friction moment is

$$\Delta P_1 = \frac{M}{h} = R\,\frac{\mu_O\,r_O}{h}$$

The increment of bearing load at O resulting from ΔP_1, is

$$\Delta R_1 = \sqrt{(\Delta H_1)^2 + (\Delta L_1)^2}$$

$$= \sqrt{\Delta P_1{}^2\,(\sin^2\phi + \cos^2\phi)} = \Delta P_1$$

and the incremental friction moment is

$$\Delta M_1 = \Delta R_1\,\mu_O\,r_O = \Delta P_1\,\mu_O\,r_O$$

This moment requires a second increment of load from the hydraulic cylinder:

$$\Delta P_2 = \frac{\Delta M_1}{h} = \Delta P_1\,\frac{\mu_O\,r_O}{h}$$

$$= \frac{R\,\mu_O\,r_O}{h}\left(\frac{\mu_O\,r_O}{h}\right) = R\left(\frac{\mu_O\,r_O}{h}\right)^2$$

Repeating the process gives

$$\Delta P_3 = R\left(\frac{\mu_O\,r_O}{h}\right)^3$$

It is apparent that the total load in the hydraulic cylinder due to the friction at joint O can be represented as the sum of an infinite geometric series in which the first term is $R\mu_O r_O/h$, and the ratio of one term to its preceding term is $\mu_O r_O/h$. The sum of this series is

$$P_O = \Delta P_1 + \Delta P_2 + \Delta P_3 + \cdots$$

$$= R\,\frac{\mu_O\,r_O}{h} + R\left(\frac{\mu_O\,r_O}{h}\right)^2 + R\left(\frac{\mu_O\,r_O}{h}\right)^3 + \cdots$$

$$= \frac{R\,\frac{\mu_O\,r_O}{h}}{1 - \frac{\mu_O\,r_O}{h}} \qquad \text{(2)}$$

Similarly, the load in the cylinder due to the friction moment at joint B is

$$P_B = \frac{P_O\,\frac{\mu_B\,r_B}{h}}{1 - \frac{\mu_B\,r_B}{h}}$$

At joint C

$$P_C = \frac{P_O\,\frac{\mu_C\,r_C}{h}}{1 - \frac{\mu_C\,r_C}{h}}$$

The total load required to move the strut is, then,

$$P_t = P + P_O + P_B + P_C$$

$$= \frac{Fa}{h} + \frac{R\,\frac{\mu_O\,r_O}{h}}{1 - \frac{\mu_O\,r_O}{h}} + \frac{\frac{Fa}{h}\left(\frac{\mu_B\,r_B}{h}\right)}{1 - \frac{\mu_B\,r_B}{h}} + \frac{\frac{Fa}{h}\left(\frac{\mu_C\,r_C}{h}\right)}{1 - \frac{\mu_C\,r_C}{h}} \qquad \text{(3)}$$

The effect of shear forces resulting from nonuniform bearing load distributions have been neglected.

Equation 3 shows that P_t decreases with smaller values of a/h and with smaller values of the coefficients of bearing friction and the bearing radii. It should be noted that the weight penalty for inserting antifriction bearings in lieu of plain bearings at the joints may exceed the weight cost for increasing the hydraulic cylinder size in order to overcome the friction.

The magnification of load as illustrated in this example, and expressed as an infinite series, has important applications in structural analysis. Much time is often spent in attempts to estimate the magnitude of secondary effects. In many cases these secondary effects can be expressed as an infinite series which can be summed in a single term.

How Friction Affects

Column End Restraint

In the design of columns, *Fig.* 2, friction is helpful in increasing the allowable load by increasing the end restraint. The familiar Euler formula giving the buckling load of a column is

$$P_{cr} = c\,\frac{\pi^2\,EI}{l^2} \qquad \text{(4)}$$

where $c = 1$ for pinned ends, $c = 4$ for fixed ends, and $c = 2.05$ for one end pinned and the other fixed. In practice c seldom exceeds 2.

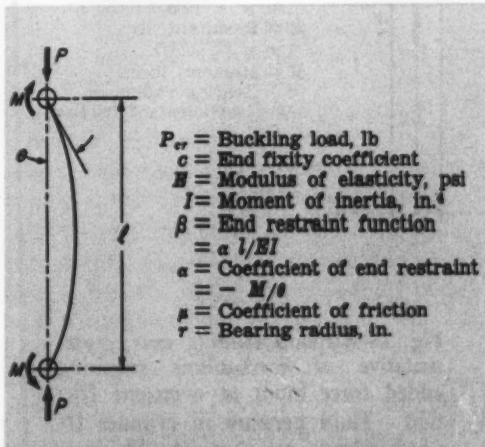

Fig. 2 — Column with end moments resulting from friction

The coefficient c depends to some extent upon the amount of friction in the terminals of the column and will increase as the amount of friction in the joint increases, thus increasing the buckling load. However, the magnitude of the restraint offered by the frictional end moments at the buckling load and the effects of vibration may be difficult to determine, since they depend upon the actual load on the column. It is to be noted that c is also dependent upon the stiffness of the supporting structure and this effect may actually supply negative restraint (destabilizing).

The restraining effect of friction in the column extremities is frequently neglected because of certain other factors which tend to reduce the allowable load. For example, initial eccentricities and initial bow (of the order of 0.015-inch per foot of column length) will always exist in real columns and will produce secondary bending stresses. When these increased stresses exceed the proportional limit stress a reduction in modulus E occurs, thus reducing the allowable column load. These eccentricities are frequently difficult to determine and hence are usually neglected. However, the effect of friction on the allowable load or on the fixity coefficient for equal end restraints can be determined.

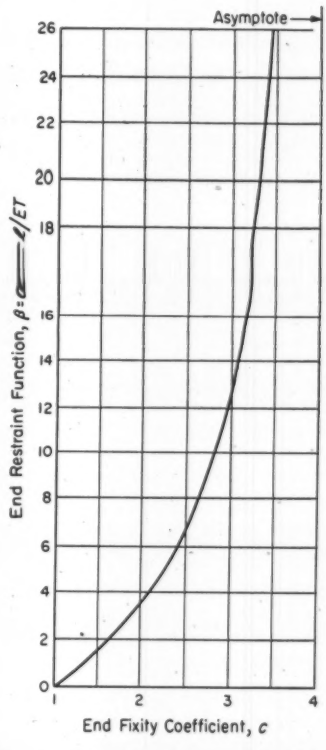

Fig. 3—Column end restraint function β versus end fixity coefficient c

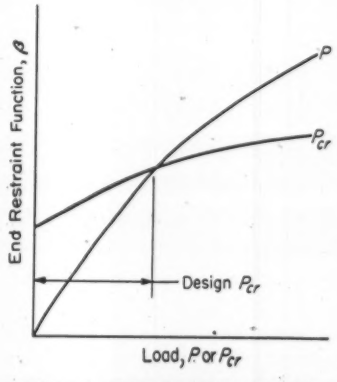

Fig. 4—Relationship of end load P and buckling load P_{cr} to end restraint function β

With the help of *Reference* 1*, the following expression can be developed:

$$\frac{1}{\beta} = -\frac{1}{\pi\sqrt{c}} \tan\frac{\pi\sqrt{c}}{2}$$

$$= \frac{1}{\pi\sqrt{c}} \tan\left(\pi - \frac{\pi\sqrt{c}}{2}\right) \quad \ldots\ldots (5)$$

Equation 5 gives the relationship between the restraint function β and the fixity coefficient c. When the column ends are held fixed, $\beta = \infty$, and from Equation 5, $c = 4$. When the terminals are pinned, $\beta = 0$, and by Equation 5, $c = 1$. The relationship between c and β given by Equation 5 is plotted in *Fig.* 3.

The restraining friction moment is given by

$$M = P\mu r \quad \ldots\ldots (6)$$

Then, ignoring the minus sign in the definition of α,

$$\beta = \frac{\alpha l}{EI} = \frac{\frac{M}{\theta} l}{EI}$$

$$= \frac{P\mu r l}{EI\theta} \quad \ldots\ldots (7)$$

Fig. 4 shows a representative graph of P and P_{cr} versus β. The curve for P versus β, Equation 7, is usually determined from test. The curve for P_{cr} versus β is plotted from Equation 4 for which c values are supplied by *Fig.* 3 (Equation 5). The design value for P_{cr} occurs at the intersection of the two curves. Alternatively, direct column tests can be employed. An empirical value of c can then be directly calculated from Equation 4.

How Friction Affects
End Moments in Links

In this case friction has a detrimental effect on the strength of the part. In *Fig.* 5 member *AB* is rotating with respect to *BC* and each member carries an axial load. Load P produces a tangen-

*References are tabulated at end of article.

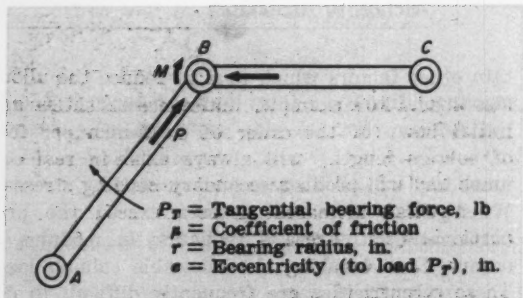

Fig. 5—Rotating end-loaded link subjected to bending moment resulting from joint friction

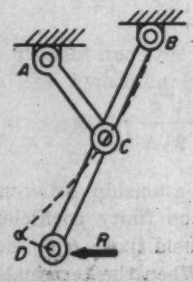

Fig. 6—Loaded linkage in which friction at joint C causes bending moment on member AC

tial force on the bearing:

$$P_T = P\mu \quad (8)$$

Also, a friction moment is transmitted into member BC by reaction of tangential force P:

$$M = P\mu r \quad (9)$$

This is equivalent to applying an eccentric load to member BC with an eccentricity:

$$e = \mu r \quad (10)$$

Another example is shown in *Fig.* 6. Load R causes deflection of member BCD, rotation at joint C, and consequently a friction moment at joint C. Hence an end moment results on member AC.

In analysis of a column on which an end moment is acting, bending stresses resulting from the end moment and magnified by the axial load should be determined. Also, the interaction of the direct column stresses limited by the buckling stress with the bending stresses should be considered. The maximum moment for this case, illustrated in *Fig.* 2, is

$$M_{max} = \frac{M}{\cos \frac{l}{2\sqrt{\frac{EI}{P}}}} \quad (11)$$

and occurs in the middle of the beam column.[2] In particular, the section adjacent to the terminal of a member where failures often occur should be analyzed for combined axial and bending stresses. The applied bending stress due to friction is often inadvertently neglected with serious consequences.

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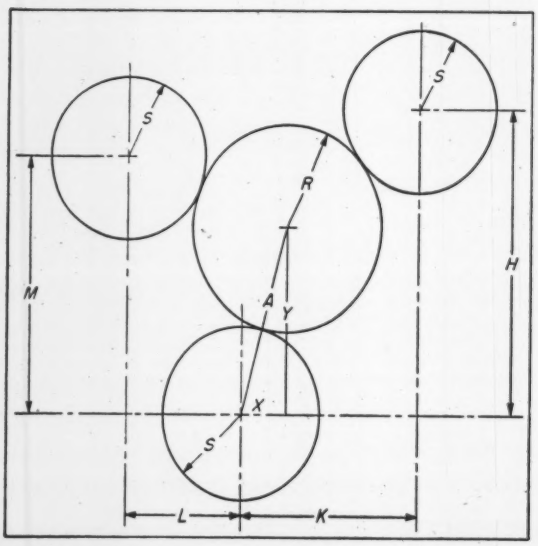
1. S. Timoshenko—*Theory of Elastic Stability*, First Edition, McGraw-Hill Book Co. Inc., New York, 1936, Pages 17 and 90.
2. Raymond J. Roark—*Formulas for Stress and Strain*, Second Edition, McGraw-Hill Book Co. Inc., New York, 1943, Table VI.

Tips and Techniques

Circle Locations

GIVEN: three equal-diameter circles, spaced asymmetrically. Problem: to find the center location and size of a circle tangent to all three.



This problem can occur in friction wheels and in multiple-spindle heads. Equations are:

$$R = \sqrt{X^2 + Y^2} - S$$

$$X = \frac{MP - HQ}{2E}$$

$$Y = \frac{LP + KQ}{2E}$$

where $P = H^2 + K^2$; $Q = M^2 + L^2$; and $E = HL + MK$.—JOSEPH KENDZIORA, *Marcus Engineering Co., Detroit, Mich.*

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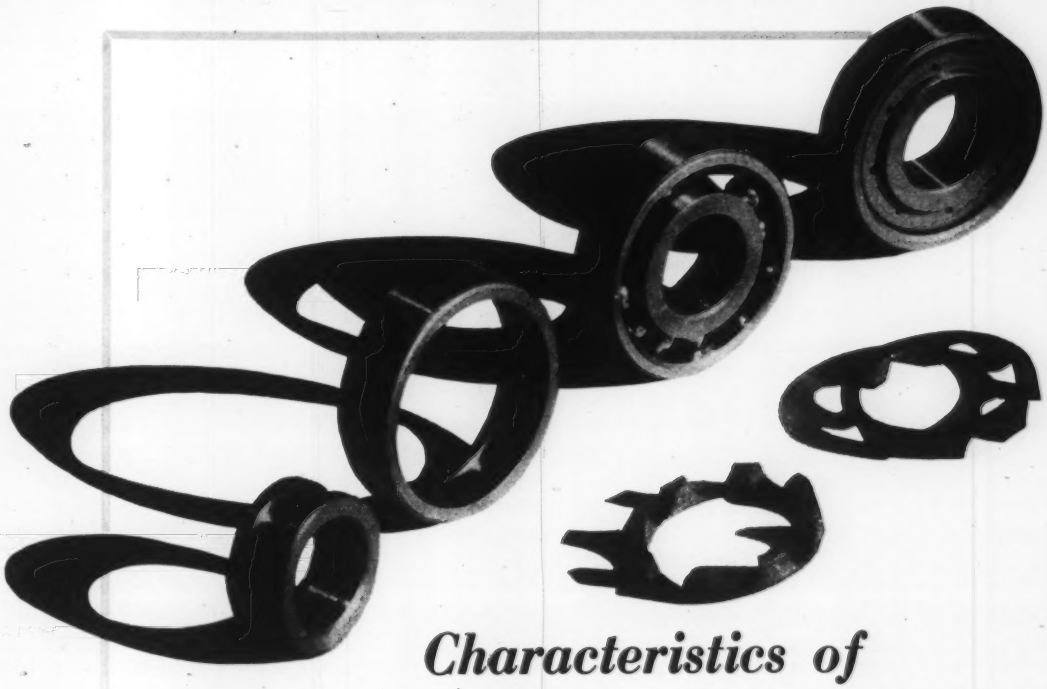


Characteristics of

Basic Ball Bearings

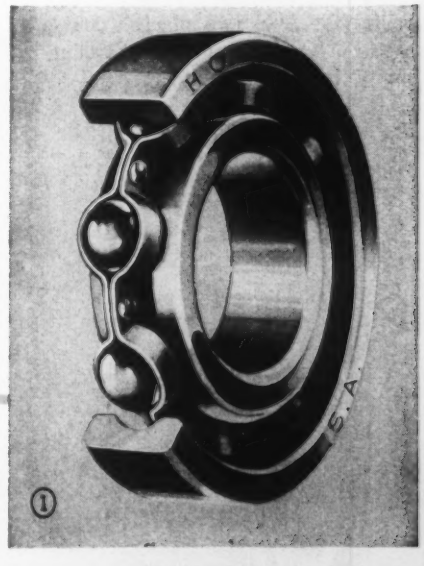
A review of fundamental types of ball bearings, emphasizing performance characteristics

By Johnny Riddle,
Tulsa, Okla.

DEMANDS for bearings suited for greater speeds, improved accuracy, longer life, higher temperature and better sealing have caused corresponding improvements in ball bearings produced today. These improvements are made possible by higher standards in metallurgical control, production techniques and stabilization of lubricants.

This article summarizes basic and modified types of bearings, and considers variables of ball-bearing design which affect performance. It can serve as a guide to selection of general types. Specifications which should be considered before final selection include deviations in axial and radial fitup, cage properties and designs, special metals, special greases when bearings are prepacked and sealed for life, angularities and, if involved, preloads.

Also to be considered is the special work many bearing manufacturers are prepared to do in order to adapt ball bearings to unusual requirements.



① Single-row radial, deep-groove design

Single-Row Radial, Deep-Groove Design

This basic type contains the maximum number of balls that can be introduced by eccentric displacement of rings—without filling-slots. Well balanced, it is suited for an almost infinite range of mounting de-

signs, with two-direction thrust capacity, *Fig.* 1.

The most widely used ball bearing design, it is produced in numerous modified types by nearly all manufacturers. It is available in extra-light, light, medium and heavy series, also in grades ABEC-1 through 7 and 9. Standard steel and many special cage materials and designs are available.

Critical design variables include intentional variations in cage design, radial fit-up and osculation (relationship of ball and ball groove), and these in turn sharply influence radial and thrust capacities, friction, speed ranges, etc.

It is produced in a wide assortment of open, sealed, shielded or snap-ring designs and combinations thereof.

Single-Row Radial, Filling-Slot Design

In this ball bearing, radial capacity is increased in ratio to the higher number of balls, *Fig.* 2. Thrust capacity is less than that of a deep-groove radial bearing in equal size and series, but the two are dimensionally interchangeable.

Whether or not the extra radial capacity is a straight-line function is a point of controversy among bearing engineers, there being involved factors beyond the mere relationship of ball size and number. However, the unit is often selected for its theoretically higher radial rating, though at more moderate speeds.

It is not inherently suited to extremely high speeds, and seldom if ever for ultraprecise mountings, though certain select units are cataloged.

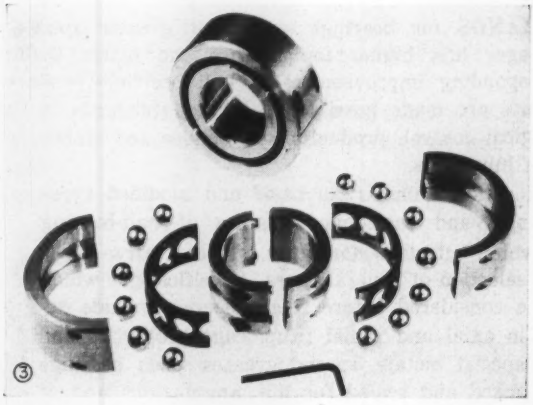
This type is widely used, in modified design, in pillow block bearings, particularly the so-called wide inner ring series.

Greater number of balls generally requires a change in separator design, compared with the deep-groove radial non-filling-slot bearing.

②

Split Bearings

Split ball bearings are another type which allows greater capacity due to a larger number of balls, *Fig.* 3. In these bearings the outer ring is broken through the cross section in one place (single fracture type), or both inner and outer rings are fractured in two places (double fracture type), to permit introduction of balls and retainer.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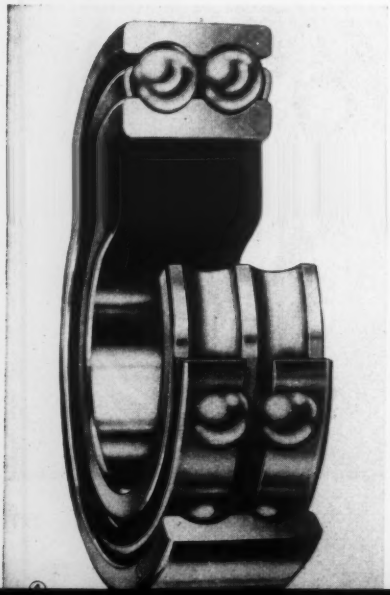

④

Double-Row Rigid

Intended for relatively heavy service, this type is designed for radial, thrust and angular loads, *Fig.* 4. Properly, double-row rigid bearings have radial, converging or diverging lines of contact, with or without filling-slots, and should be identified as such. Nevertheless, a rather wide range of design interchangeability exists.

These bearings are generally applied for load

capacity, not for great speeds. Normally made to ABEC-1 standards, they are available from some manufacturers in higher grades.

They are produced by some manufacturers with single or double metal shields, but seldom in sealed construction. External snap ring designs are available in some sizes, particularly the light and medium series. Producers can intentionally vary the original internal clearances for specific design requirements.

A rather wide variety of cage materials and designs characterizes this basic type.

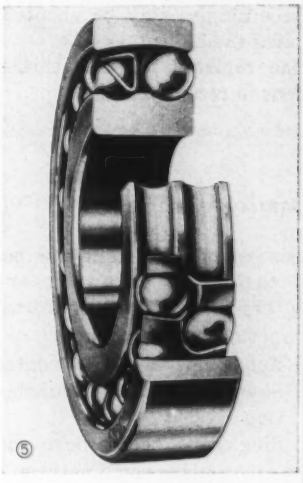
Double-Row, Self-Aligning

This type is characterized by a two-row assembly, with conventional ball grooves for the inner ring, and with the inside surface of the outer ring formed to a spherical contour, *Fig.* 5. It is generally tabulated with a radial capacity somewhat below that of a single-row deep-groove radial in equal size and series.

Available in straight and tapered bore, it is not inherently suited to extremely high speeds or heavy thrust loads. However, thrust capacity increases with the wider series, and manufacturers can make internal changes which extend the speed range.

Original radial fit-up is a critical design variable when it deviates from standard. Select and progressively refined units are available in some series.

This type of unit provides many compensating advantages for certain difficult designs.



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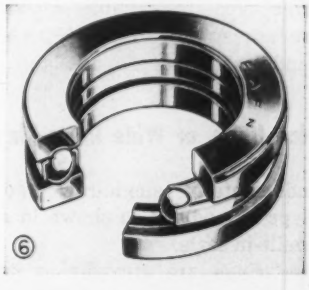
Thrust Bearings

Flat thrust bearings are designed to carry mainly axial loads, radial capacities being incidental, *Fig.* 6. Due to certain inherent phenomena, there are sharp limitations on speed, but the manufacturers, by judicious modification of internal features, are able to extend the normal speed range for many mountings.

AFBMA standards tabulate about twelve basic and modified designs. They are made in many refined series, sizes and shapes. Widely used in machine tool applications, they are ideally suited for some heavy-duty mountings.

This type is available in one and two-direction types, with or without self-aligning seats, in metric and inch dimensions, with or without grooves, *Fig.* 7.

Many individual patterns have appeared. One for example, is an angular-contact ball thrust bearing, *Fig.* 8, suitable for carrying thrust and radial loads.



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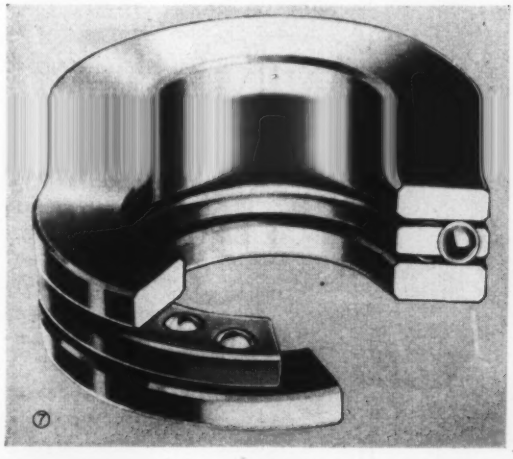

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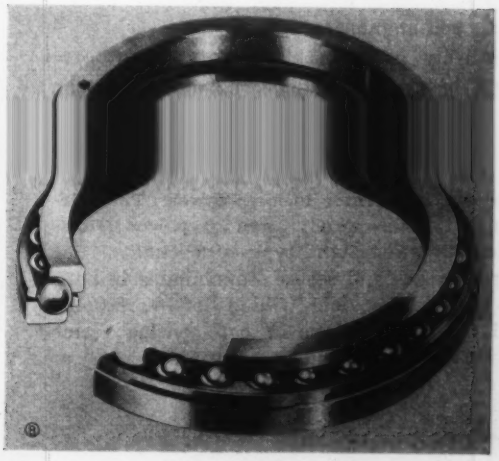
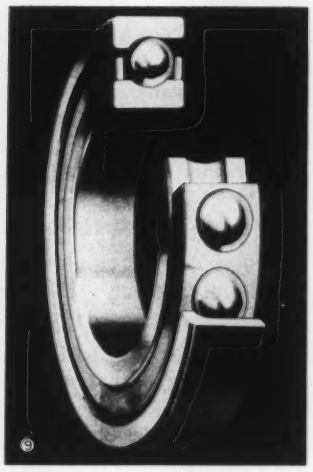


⑧

Single-Row Angular-Contact



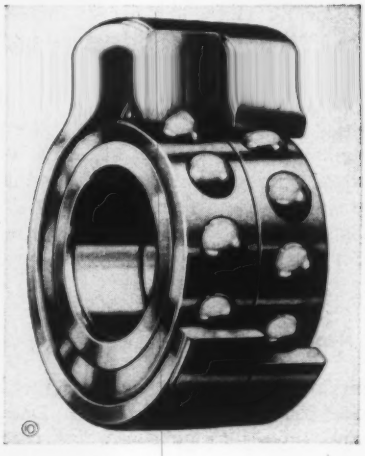
This type of single-row bearing is designed for angularity and intended to provide thrust capacity in one direction through heavy outer-ring shoulder, *Fig.* 9. Properly mounted, and when assembled into the machine, it carries combined loads. It is nonseparable.

Available in extra-light, light, medium and heavy series, it has a variety of cage properties and designs. It is also available in select and higher precision grades, sometimes with an integral flange on outer ring.

Angularity is an intentional feature of design, and may range from about 15 to 45 degrees. Thrust rating, accordingly, may be about 150, 200 or 300 per cent of rated radial load.

It has replaced the flat thrust bearing in many applications in recent years.

Duplex Bearing



Consisting of two single-row bearings, this type is designed to operate as a pair or set, with preload normally built in, *Fig.* 10. Normally, one of three designs appear in the duplex:

1. Single-row angular contact
2. Single-row radial, counterbored construction
3. Single-row deep-groove radial

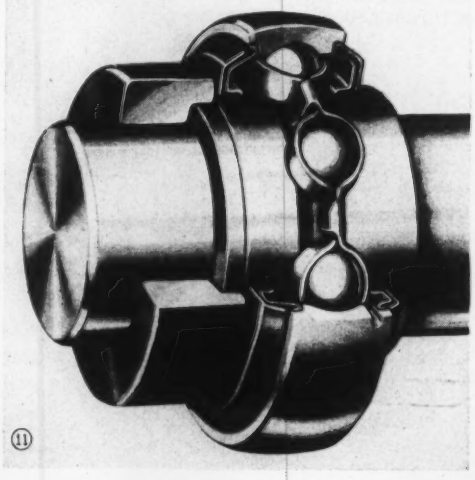
There are other minor combinations.

In the three basic arrangements (back-to-back, face-to-face, and back-to-face), and in turn with a range of angularities and fitups, the duplex bearing enables the designer to proceed in many directions.

For slow, heavy-duty service, for moderate or heavy radial loads, for single or two-direction thrust, for shock, axial and/or radial location, or high-speed super-accurate tool operations, there is a duplex bearing for the job.

This type is available in extra-light, light, medium and heavy series, in a wide assortment of refined (ABEC-1 through 9) units. Many cage materials and designs are also available.

Machine Units, or Wide Inner Rings



Fundamentally single-row radial bearings, this type is modified as shown in *Fig.* 11. Some have built-in seals.

Outer rings are straight or spherical. One provides a rigid mounting; the other is externally self-aligning in the housing.

Relatively higher seating area permits reduction in shaft fits, and supplemental collar provides even greater locking power. The self-aligning type is widely used in power transmission units; straight type occasionally.

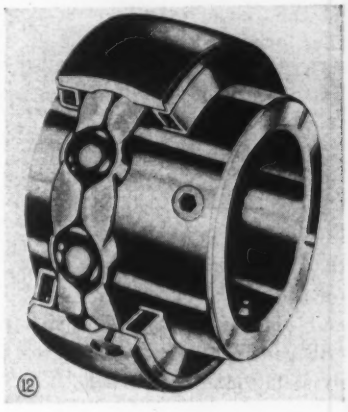
Certain sizes and series are available in both the deep-groove and filling-slot variations. Popularity of this type of ball bearing seems to be steadily increasing.

Extended Inner Ring

Basically a single-row radial design, *Fig.* 12, this type is available in deep-groove or filling-slot constructions.

Long adapted to electric motor mountings, when mounted opposed to a double-row bearing it allows free interchangeability of end bells.

Wider seating area provides necessary gripping or holding power. Thus, it is often used without locknut. The extended inner ring also serves as a reliable spacer for machine assembly. Functional qualities are similar to those of deep-groove or filling-slot radials in equal size and series.



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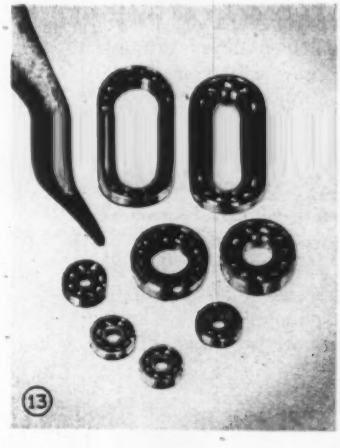
Miniature or Instrument Bearings

Making a strong bid in the fields of instrumentation and miniaturization are the assorted designs and sizes in the so-called instrument or miniature ball bearings, *Figs.* 13 through 15.



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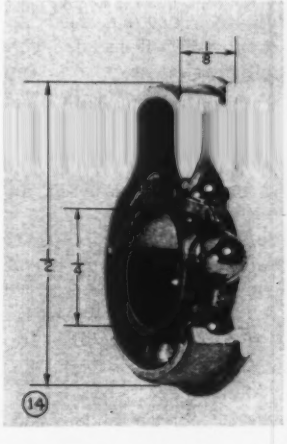


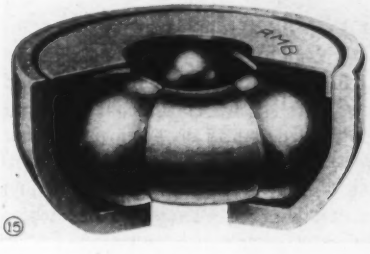
⑭

Long acknowledged for their compactness, lightness and friction-saving characteristics, these bearings are finding an ever-growing market as designers search for ways and means of improving miniature machine assemblies.

Nearly 150 sizes are available in such basic types as radial, angular-contact, pivot, thrust, flanged-radial, etc.

They are available in various ABEC grades, and some may be obtained for duplex mounting. Generally made of high-carbon chrome-bearing steel, some are available in stainless steel, others in beryllium copper.

Range of sizes continues to expand, and scope of production is extended yearly.



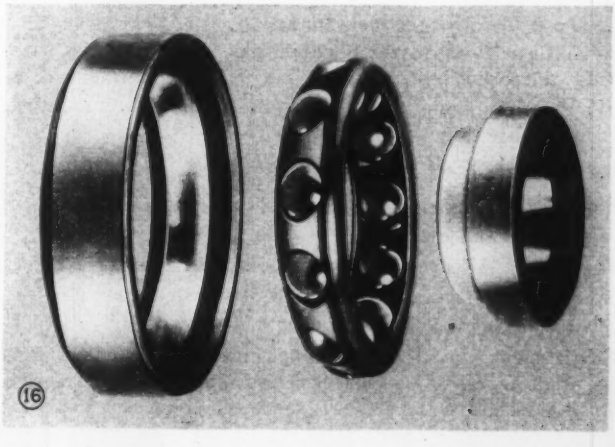
⑮

Front Wheel Bearing

Originally designed for automobile wheels, this type is now enjoying some popularity in industrial mountings, *Fig.* 16.

It is of three-piece separable construction, and becomes an angular-contact bearing when assembled into position. In car wheels these units are used in pairs, an inner and outer bearing, the larger one usually designed with an extended or wide inner ring to accommodate the customary seal.

This type is available in several sizes, but without any significant design variations.



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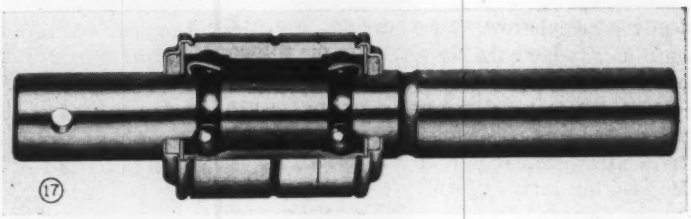
Fan and Water Pump Bearings

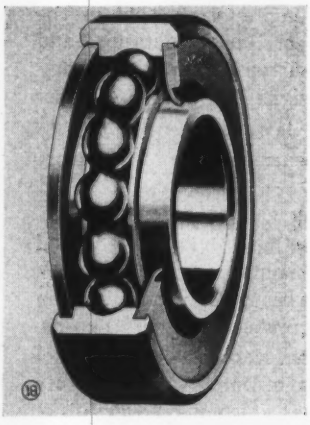


Again, this is a type of bearing originally designed for the automotive trade, but now being applied in some industrial situations, *Fig.* 17.

Unit shown is assembled with definite, angularity, thus providing good radial and axial rigidity. It is sealed for life.

About nine or ten sizes, or variations, are available, and some manufacturers will consider special plating or finishing services. It remains, of course, primarily an automotive bearing.

Aircraft Series



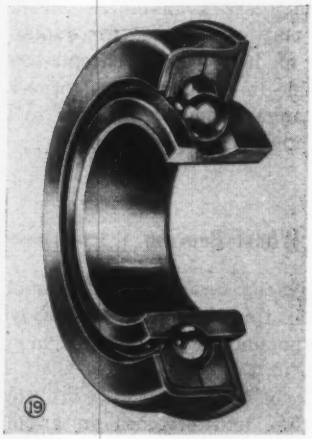
Originally designed for the aircraft industry (rod ends, track rolls, fairleads, guide rolls, pulleys, torque tubes, bell cranks, etc.), this type is now widely used in industrial mountings, *Fig.* 18.

Inch dimensions prevail, and units are in cageless (full type) construction. This restricts rotative speeds, but static and slow speed capacities are very good.

These bearings are frequently supplied with high-temperature seals and improved greases.

They constitute an increasingly popular ball-bearing series. Manufacturers offer special plating and type variations.

Unground Ball Bearings



This line of industrial ball bearings, *Fig.* 19, includes single-row, double-row, flat-thrust and angular-contact.

In reality, the units do have parts (balls) that are ground. These are normally assembled with smoothly machined races, to produce a greater degree of internal looseness than is found in a precision bearing. They are not intended for precise supports. But where elaborate seals are not desired, or where the bearing is intended as a seasonally expendable part, they prove to be very practical indeed. Too, they accommodate considerable misalignment.

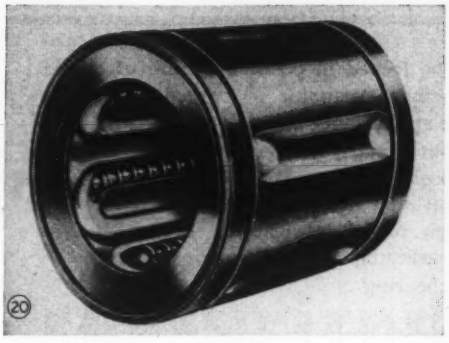
Design cost, in contrast, is only fractional, and inch dimensions are standard. Difficult problems may be approached by special considerations in metallurgy.

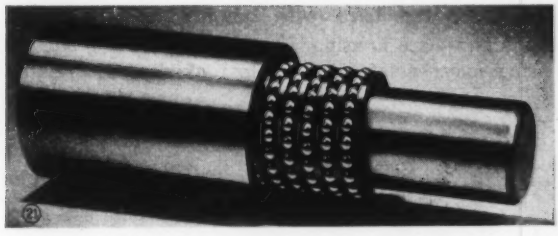
For intermediate machine mountings, where higher than unground tolerances are required but ABEC-1 refinement is not justified, there is a "ground all over" group. Many modified types are manufactured.

Linear Motion Bearings

The linear ball bushing is a type of ball bearing designed for linear motion. It overcomes problems in sliding linear movements or in using bulky and expensive wheel and track arrangements, *Fig.* 20.

Advantages over plain bushings include lower friction, elimination of binding and chatter, higher operating speeds, compactness, and unlimited travel.





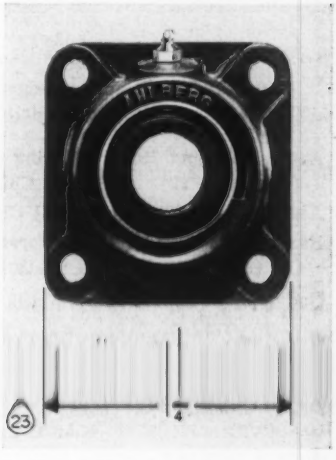
Typical applications include floating motor mounts, governors, textile twisting machines, machine-tool slides and tracers, cloth cutters, packing machine mountings, and many related designs.

Various sealing arrangements, mountings, and lubrication provisions are available in commercial and precision grades.

The ball reciprocating bearing is another type of linear motion bearing used in applications where oscillation or rotation plus longitudinal movement of the shaft occurs, *Fig.* 21. It offers high capacity in this kind of service.

Ball-Bearing Flange Unit

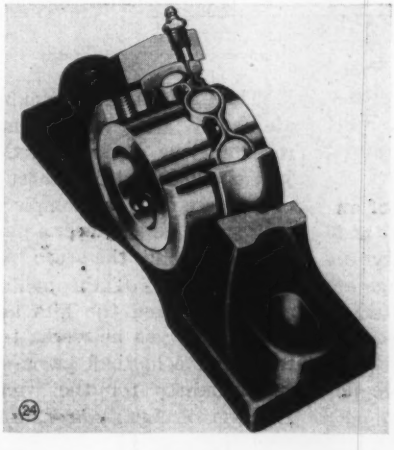
This type of bearing unit, *Figs.* 22 and 23, is very similar to the pillow block in related size and series, with capacities about equal. Bearing design, its retention, sealing arrangement, lubrication routines, and general performance are also very much like the pillow block of similar size and series.

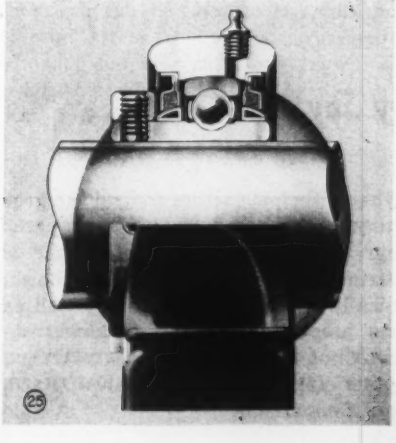


Single-Row Ball-Bearing Pillow Block

A single-row radial bearing, this type is modified to seat in a one-piece housing with built-in seals, *Figs.* 24 and 25. Bearing is inserted by means of diametral slots on side of housing.

Available generally in three series, each is intended for particular service. Seal designs and general construction may vary, but basic principle remains unchanged: a portable bearing mounting which can be carried to the location and quickly assembled into position.





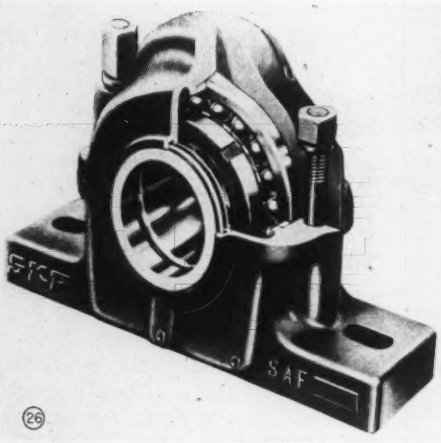
Double-Row Ball-Bearing Pillow Block

This bearing unit is a double-row, self-aligning ball-bearing design, often with tapered bore, and used with adapter assembly in two-piece housing, *Figs.* 26 and 27.

Bearing may be left free to float axially, or it may be locked in position by use of a stabilizing ring. Available in two standard series, with special housing designs available, such as floor stands, hanger boxes, etc., all related to basic design.

Some sizes and designs are furnished for either grease or oil lubrication.

Adapter assembly locks the unit through load line of bearing.



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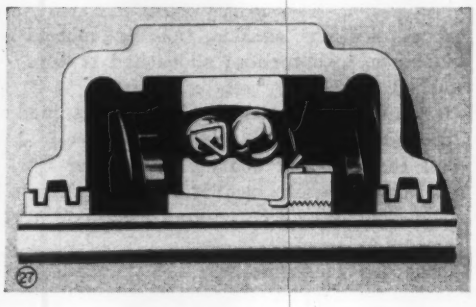
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PHOTO CREDITS

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Landis & Gyr Inc. (*Fig.* 15) ..... New York
Link-Belt Co. (*Fig.* 25,) ..... Chicago, Ill.
Marlin-Rockwell Corp. (*Figs.* 16, 17, 18) ..... Jamestown, N. Y.
Miniature Precision Bearings Inc. (*Fig.* 13) ..... Keene, N. H.
Morton Bearing Co. (*Head photo*) ..... Ann Arbor, Mich
New Departure Div., General Motors Corp. (*Figs.* 2, 10) ..... Bristol, Conn.
New Hampshire Ball Bearings Inc. (*Fig.* 14) ..... Peterborough, N. H.
Nice Ball Bearing Co. (*Fig.* 19) ..... Philadelphia, Pa.
Sealmaster Div., Stephens-Adamson Mfg. Co. (*Fig.* 12) ..... Aurora, Ill.
SKF Industries Inc. (*Figs.* 4, 5, 26, 27) ..... Philadelphia, Pa.
Split Ballbearing Corp. (*Fig.* 3) ..... Lebanon, N. H.
Thomson Industries Inc. (*Fig.* 20) ..... Manhasset, N. Y.

They Say . . .

"Three principal factors control the growth of an industry or economy—manpower, materials and money. In the application of atomic energy to industrial purposes, we believe that the shortage of technically trained manpower may well reach such serious proportions that it will control the rate of growth of the industry to a greater extent than any other single factor."—J. F. KAUFMANN, *Atomic Energy Commission*

"The great American public is quick to appreciate ability. And I have found that the public does recognize the engineer in thinking that he can do just about everything there is to be done. But the public sees only the completed product; it does not appreciate the engineer's part in it. It is as if the fans knew only the score of the ball game after it was finished. If the public could intimately see and understand the hits and runs and errors of the engineer as he works to perfect his product—to complete his ball game—its appreciation would be boundless for the wonders he performs."—EVERETT S. LEE, *editor, General Electric Review*

Nomograph simplifies stress calculations for

MACHINE DESIGN
Data Sheet

Pressurized Cylinders

By Herbert A. Magnus
Huntsville, Ala.

TANGENTIAL stress in an internally pressurized cylinder may be calculated by several methods. Wall thickness usually determines the choice of method.

Computation of stress in a thin-walled cylinder is relatively simple. Stress is usually assumed uniform throughout the wall thickness, and calculated by the well known "hoop-tension" formula:

$$s_t = p \frac{D_i}{D_o - D_i} \quad \ldots\ldots (1)$$

As wall thickness increases, however, the preceding assumption introduces greater error. Therefore, a more complete theory of stress distribution and, hence, a more complex calculation are required for stress determination in a thick-walled cylinder.

Tangential stress in a cylinder, according to Lame, is

$$s_t = p \frac{D_i^2}{D_o^2 - D_i^2} \left(\frac{D_o^2}{D_x^2} + 1 \right) \quad \ldots\ldots (2)$$

Terms are defined in the accompanying *Nomenclature*.

By making $D_x = D_o$, maximum tangential stress can be found. Equation 2 becomes

$$s_t = p \frac{D_o^2 + D_i^2}{D_o^2 - D_i^2} \quad \ldots\ldots (3)$$

Divergence of results obtained by the two methods, Equations 1 and 3, is shown graphically in *Fig.* 1. The simplified method, Equation 1, increases in error to 5 per cent at a diameter ratio of 1.10, and rises even more rapidly beyond this point.

The nomograph, *Fig.* 2, simplifies stress calculation for internally pressurized cylinders of any wall thickness. It is based on the more complete and accurate method of determining stress, Equation 3. The simpler expression, Equation 1, need not be considered.

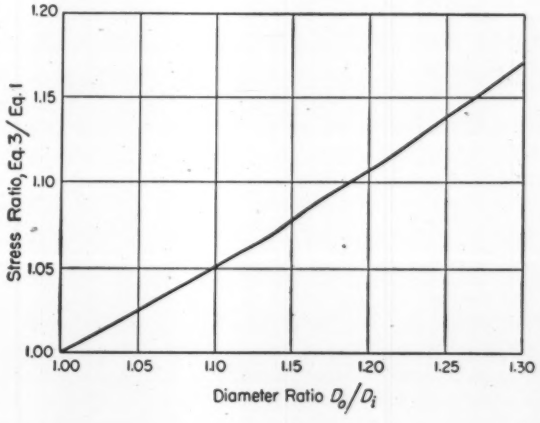
The nomograph can be used to calculate maximum tangential stress if internal pressure and outside to inside diameter ratio are known. Conversely, a safe diameter ratio can be determined from known pressure and maximum allowable stress.

Example: Assume inside diameter D_i = 2 in., internal pressure p = 12,500 psi and the maximum allowable stress s_t = 32,500 psi. To find outside diameter D_o, locate 12,500 psi on the p scale, 32,500 psi on the s_t scale, and connect these two points by a straight edge. The diameter ratio scale is intersected at 1.5. Multiplying inside diameter D_i by 1.5 yields a value of 3 in. for outside diameter D_o.

Nomenclature

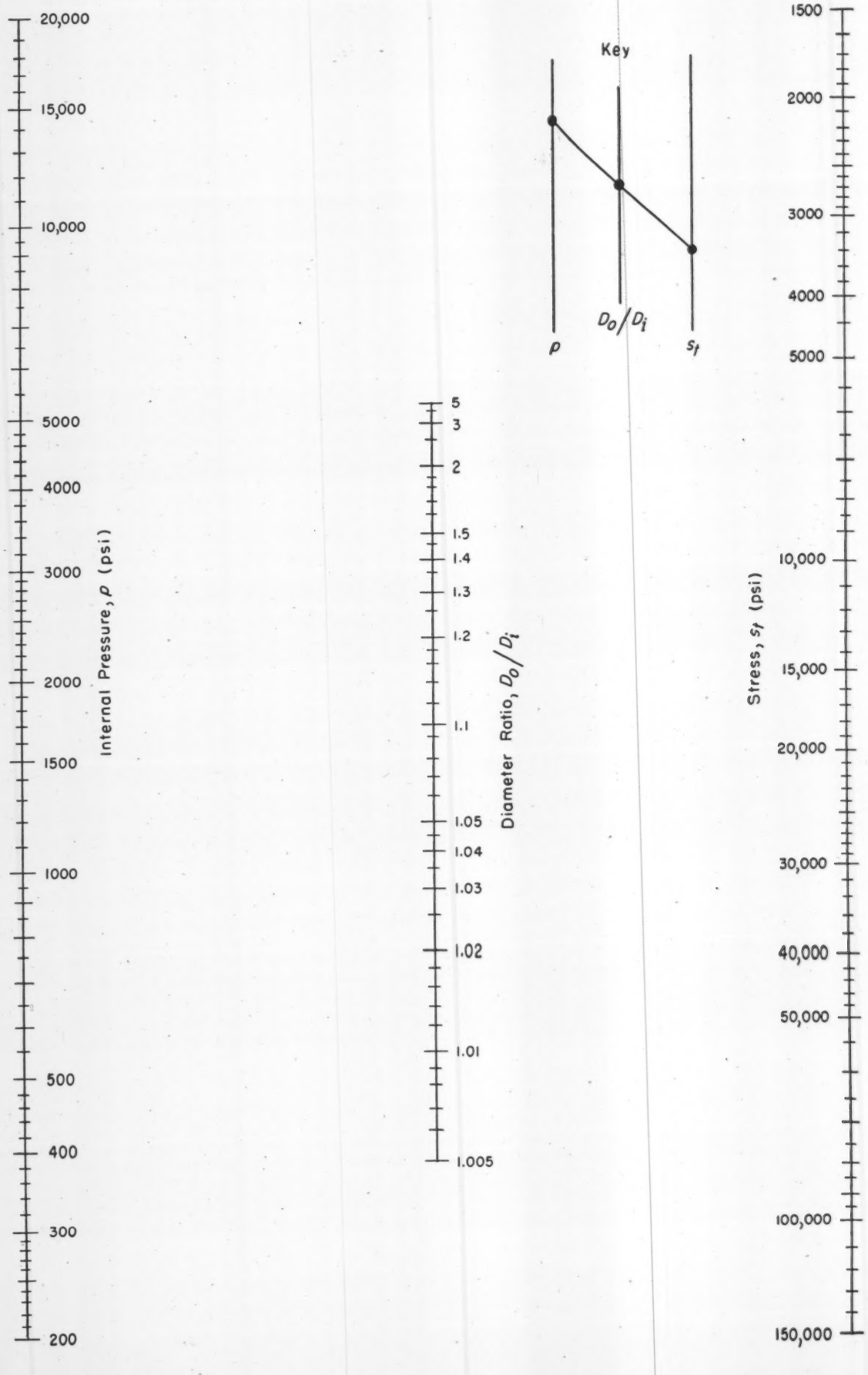
D_o = Outside diameter of cylinder, in.
D_i = Inside diameter of cylinder, in.
p = Internal pressure, psi
$D_x/2$ = Radius to any point in the cylinder wall, in.
s_t = Tangential stress in the cylinder wall, psi

Fig. 1—Graph showing how stress values computed by Lame theory exceeds those given by simple hoop-tension formula



Cylinders

Fig. 2—Nomograph for solving cylinder problems in terms of ratio of outside diameter to inside diameter, maximum internal pressure, and maximum tangential stress



DESIGN ABSTRACTS

Light weight, high strength, corrosion resistance and increasing availability are factors to consider in . . . .

Designing for Magnesium

By E. V. Schirmer
Chief Design Engineer
Brooks & Perkins Inc.
Detroit

BASICALLY, designing in magnesium is no different than designing in steel or aluminum. Magnesium structures react under applied loads in much the same manner as other metals. Magnesium alloys are available in a variety of forms such as rolled sheet and plate, extruded sections, castings, and forgings.

Design Considerations: Magnesium is the lightest of all structural metals, *Fig.* 1. Aluminum is 50 per cent heavier, and steel is approximately 4½ times as heavy as magnesium. On a strength-weight basis, *Fig.* 2, magnesium is superior to the other materials except for the high-strength aluminum alloys such as 7075 (formerly 75S) and 2024 (24S). Magnesium also holds a definite advantage over steel and aluminum on a stiffness-weight basis, *Fig.* 3. Advantages shown by these comparison charts, however, can be realized only if increases in cross-section area of the magnesium part is made by increasing depth of the section.

Selection of Alloy: Most commonly used wrought alloy is AZ31. It is used for rolled sheet and plate, extruded shapes and tubing, impact extrusions and forgings. AZ31 alloy has very good strength and fatigue characteristics. Rolled sheet and plate material may be readily formed, deep drawn, and welded except for sheet furnished in hard-rolled H24 condition. Hard-rolled sheet has higher physical properties but should not be used for parts requiring severe forming or welding since it loses the hard-rolled properties when heated above 350 F. AZ31 extrusions have the same physical properties as the annealed sheet material and may also be formed and welded. M1 magnesium alloy is used for rolled sheet and extruded sections. It has lower strength characteristics than AZ31 alloy but somewhat better corrosion resistance. In both forms it has excellent hot formability and weldability.

Extrusions are also available in AZ80 and KZ60 alloys. These alloys are both heat-treatable and have higher physical properties than AZ31 alloy. Extrusions of these alloys are not recommended for forming or welding operations but are particularly adaptable for highly stressed parts which do not require forming.

The most commonly used magnesium casting alloys, AZ63A and AZ92, are both heat-treatable and have good casting characteristics. AZ63A alloy has maximum toughness and ductility combined with good yield strength. AZ92 alloy has the highest yield strength, fair pressure tightness, and is weldable. AZ91A alloy is commonly used for die castings, while AZ91C alloy is used for sand castings and has properties intermediate between AZ92 and AZ63 alloys.

Several casting alloys, such as EK30A, EK41A and EZ33A, contain small percentages of rare earths. These alloys are especially recommended for use at elevated temperatures from 350 to 500 F. They have good creep strength at elevated temperatures, good pressure tightness, and are heat-treatable.

Fabricating Methods: Magnesium sheet can be worked by conventional methods, such as press-brake forming, stretch forming, die forming, rubber forming and spinning. While simple forming can be done at room temperature with liberal bend radii, most magnesium forming is done at elevated temperatures of from 350 to 600 F. Hot forming permits use of bend radii as sharp as 1½ times thickness and makes severe forming operations possible.

When hot, magnesium sheet material may be deep drawn in a single stage to much greater depth than other metals. Since magnesium anneals at the 550-650 F temperatures used, the draw is completed in one operation. A chart of suggested design factors, *Fig.* 4, has been prepared as a guide.

Magnesium extrusions are available in standard shapes such as angles, channels, I-beams, and tubing. The designer can often simplify construction and reduce the fabrication time required for a unit by using special extrusions. Die costs are relatively low; for production parts, the cost of a die is usually insignificant compared to the reduction in fabricating costs.

Magnesium castings have good strength characteristics. Magnesi-

um alloys were first used in castings, and improvement of alloys and casting techniques has steadily kept pace with the rest of the industry.

Magnesium parts may be assembled by several methods such as riveting, bolting, spot welding, arc welding and bonding.

Riveting practices for magnesium are the same as those for aluminum except that 5056 (56S) aluminum alloy rivets are used to reduce the possibility of galvanic corrosion. When magnesium is riveted to magnesium, both parts should be primed prior to riveting to prevent corrosion on the facing surfaces. When moisture traps may occur, especially when magnesium is riveted to a dissimilar metal, a sealing compound should also be used.

Steel fasteners used in magnesium assemblies should always be zinc or cadmium plated to reduce possibility of galvanic corrosion. Bolts are frequently used to attach steel fittings to magnesium assemblies. For normal service conditions, zinc-chromate primer applied to both the magnesium and the steel part prior to assembly provides sufficient corrosion protection. If severe service conditions are expected, insulating tape or gasket material should be specified under the steel fitting. If bolts are to be installed in tapped holes in magnesium parts, it is advisable to use stainless-steel wire inserts or plated steel bushings to obtain better shear-out and wear characteristics. For permanent fastenings, bolts may be threaded directly into magnesium provided a minimum thread engagement of 2 diameters is used. For all tapped holes in magnesium the coarse-thread series should be used.

Next to riveting, arc welding is the most commonly used assembly method. All arc welding is done by the shielded-arc method with either helium or argon gas for shielding. Efficiencies of 85 to 95 per cent may be expected of weld metal compared to the parent metal. Ductility of magnesium welds is also very good. All magnesium parts should be stress-relieved after arc welding to prevent stress cracking.

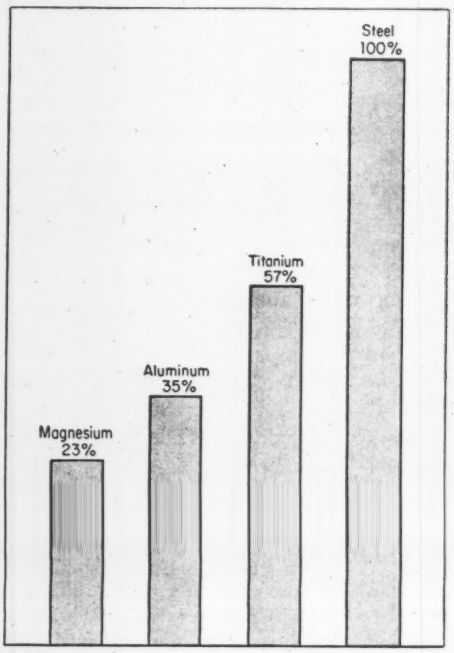


Fig. 1 — Comparison of weights of equal volumes of metals

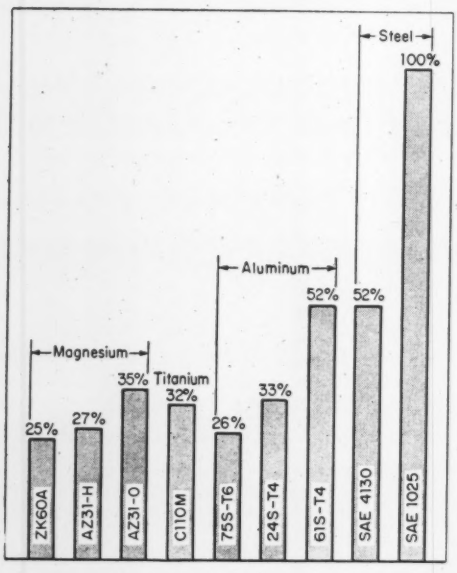


Fig. 2—Comparison of weights for equal strength of rectangular beams of constant width

Finishing Methods: Several chemical treatments may be used to provide good paint adhesion and increased corrosion protection. These include chrome-pickle (Dow No. 1), dichromate (Dow No. 7), galvanic anodize (Dow No. 9), and sealed chrome-pickle (Dow No. 10). The chrome-pickle treatment is widely used to protect semifinished forms, such as sheet and extrusion, during shipment and storage. It is not widely used as a paint base except on M1 alloy since it requires close control. The dichromate treatment is the most widely used as a paint base and provides good adhesion.

HAE and Dow No. 17 treatments are new electrolytic processes which deposit a hard ceramic coating on the metal. These coatings provide excellent resistance to corrosion, abrasion and heat. They also provide a good paint base and tend to absorb the paint into the coating. Since these coatings are very hard, they tend to spall during riveting operations and on the compression side of panels. This may be overcome by use of a thin electrolytic coating covered by paints which tend to

reduce spalling. Iridite No. 15 is a new chemical immersion treatment which deposits a dark brown coating on AZ31 alloy similar to the dichromate coating. It has the advantage of requiring only a very short treatment time but does require careful rinsing to prevent paint blistering.

Most commonly used primer is zinc-chromate primer. Wash primers have been used with good results even on bare metal but are not approved for use on Government equipment. Several other primers such as AP 10 have also been used with good results.

Most common finish paints are baked enamels and lacquers. Applied over a well-prepared primed surface, these finish paints will give long and satisfactory service.

In addition to these protective systems, plating is now available. A thin film of zinc is chemically deposited on the magnesium part. This step is immediately followed by a standard plating. This makes available a good decorative finish. However, at the present time, plating cannot be recommended as a finish to protect the metal against severe corrosive conditions. Suitable paints are considered better for this purpose.

Applications of Magnesium

There has been a great demand for light-weight pressurized cases for electronic equipment in aircraft. Many such cases have been designed in magnesium and have proved very successful.

Most magnesium pressure cases being produced today use castings for cover mounting flanges. Castings were originally considered impractical for this use because of porosity in the base metal and also in weld joints between the casting and the shell. The results with AZ92 alloy castings have been very good. Units that develop leaks due to porosity are impregnated after fabrication and machining. Some experimental work has been done with EZ33A castings (British ZRE1 alloy) with excellent results. This alloy is noted for its freedom from microporosity. When welded to AZ31A sheet, a very sound pressure-tight weld is obtained.

Magnesium cooler-plate assemblies, *Fig.* 5, are also a new development in electronic equipment. In use, electronic components to be cooled are mounted on the surface of the hollow plate assembly, and air is passed through the interior spaces to carry off heat. This plate assembly is made up of two finned sections joined face-to-face by arc welding. Sheet-metal headers are welded to each side to provide for attachment of air ducts. Outer surfaces of these plates are machined after welding to provide a flat area for equipment mounting. Flatness and high-quality surface finish are very important since heat transfer from the components to the plate take place by direct contact. Magnesium was selected

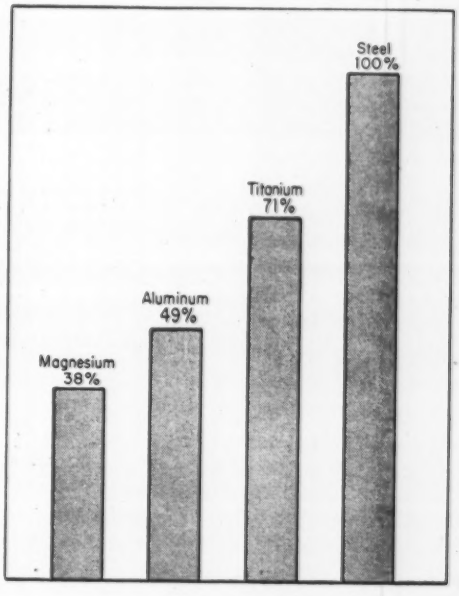
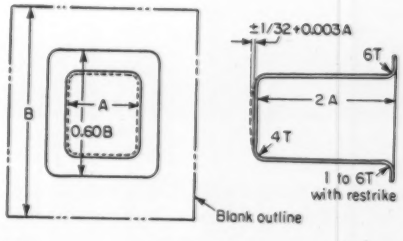


Fig. 3 — Comparative weights for equal stiffness in rectangular beams of constant width



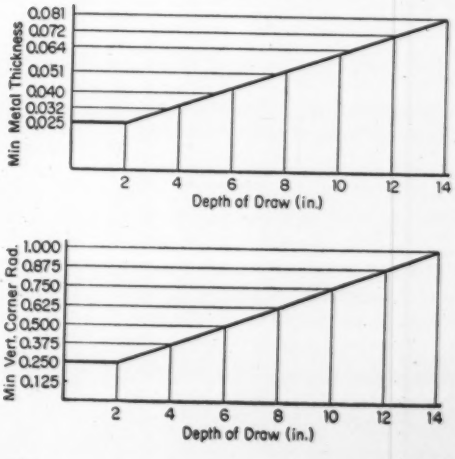


Fig. 4—Suggested design factors for deep-drawn magnesium parts

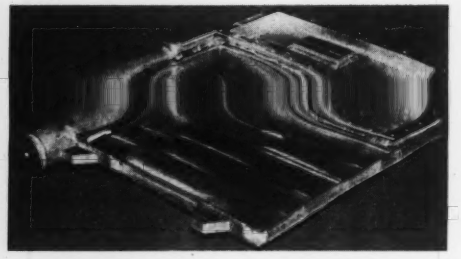


Fig. 5—Left — Magnesium cooler - plate assembly for electronic mountings

Fig. 6—Copper-plated magnesium housing

for this application, for its light weight and its excellent heat-conducting properties.

Copper plating has been done successfully for some time, but early platings had poor adhesion to the metal surface. The electronic housing shown in *Fig.* 6 was copper plated by a recently improved process. It was then assembled and hermetically sealed by sweating a copper strip over the joint. On similar test units, this seal strip has been peeled off and replaced several times with no damage to the plated surface.

Magnesium is being used extensively for radar reflectors. There is a double gain: the weight-saving in the basic unit, and a reduction in size and weight of the driving unit. The antenna shown in *Fig.* 7 is of particular interest since it was designed to withstand high accelerations. The back-up section is fabricated by arc welding and is heavily reinforced for rigidity, while the outer reflecting surface is attached to the weldment by bonding.

With increasing aircraft and missile speeds, temperature has become one of the new problems to be faced by designers. External skins and much of the primary structure must be designed for high temperatures. Present aluminum alloys lose strength rapidly above 300 F. The new titanium alloys do an excellent job from 700 to 1000 F. Magnesium-thorium alloy HK31 fills the gap in the 300 to 700 F temperature range. *Fig.* 8 shows comparative strength of HK31 magnesium, 2024 (24S) and 7075 (75S) aluminum, and A-55 titanium at elevated temperatures.

This new HK31 alloy is available in rolled sheet and plate form. It may be obtained in annealed or H24 hard-rolled condition. Annealed sheet may be solution heat-treated to the T6 condition after fabrication for improved properties at temperatures exceeding 500 F. Fabrication methods for HK31 alloy are basically the same as those used for AZ31 alloy: it may be spot welded, arc welded, formed and deep drawn. Stress relief after welding should be at approximately 200 F higher than for AZ31, except for the H24 material which should not be stress relieved at temperatures higher than 620 F. Standard finishes may be applied to HK31 sheet material except that the dichromate treatment cannot be used and is replaced by the chrome-pickle or sealed chrome-pickle treatment.

From a paper entitled "Design Principles in Magnesium" presented at the 11th Annual Convention of the Magnesium Association in in New York, October-November 1955.

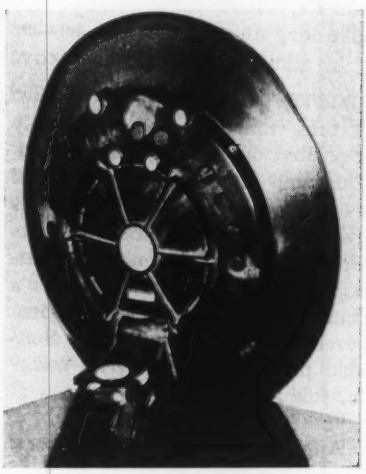


Fig. 7 — Magnesium radar antenna

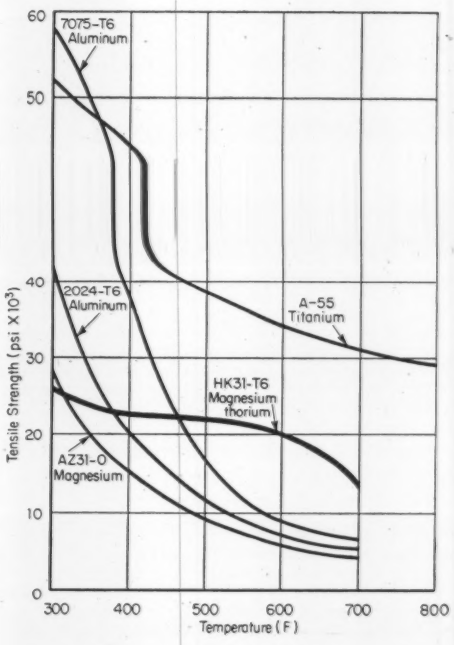
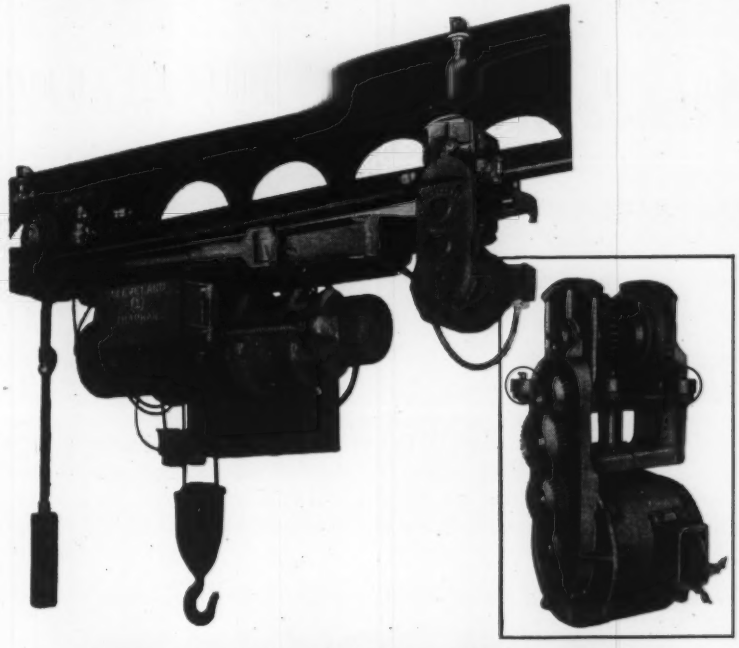


Fig. 8 — Tensile strength of several metals at elevated temperatures

BEARING TIPS by McGill



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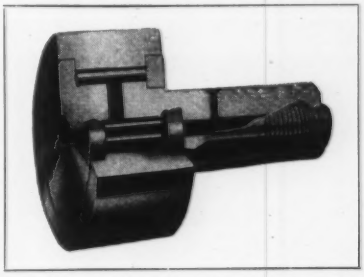

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—ITEM 219—

Applying Notch Tensile Tests

to solution of design problems

By J. D. Lubahn
Research Associate
General Electric Research Lab.
Schenectady, N. Y.

PRINCIPAL value of notch tensile testing to engineering problems is to distinguish between "notch-ductile" and "notch-brittle" behavior of loaded members. When the metal is sufficiently notch ductile, a satisfactory safeguard against fracture for notched parts subjected to static tension is to design for an average stress on the minimum section equal to the tensile or rupture strength, divided by a suitable safety factor. This procedure results in considerable local plastic flow, of course, guaranteeing only against complete failure by fracturing. The safety factor, in this case, must be at least large enough to cover the variability of tensile strength among different lots of material.

It is not yet clear how to tell with certainty whether the metal is "sufficiently" notch ductile for the above design procedure to be valid. In some cases service failure has occurred at an average stress far below tensile strength, even though a small notch tensile specimen has indicated good notch ductility.

Basis for Design: For notch-ductile metals, designing on the basis of average stress is more reasonable than the classical method using elasticity theory and the condition of yielding to avoid any plastic flow, even locally. This classical method is applicable to very brittle metals, but is overconservative for metals that have even a small ductility. When the metal has some ductility, but not enough to permit the use of the average stress in design, there is no known design procedure that is applicable.

Development of a design procedure for notch-brittle metals awaits a more fundamental understanding of the various factors that govern fracture: size, stress state, strain rate, residual stress, strain gradient, etc. For engineering purposes, this understanding need not be detailed enough to be able to state the mechanism of fracture at the atomic or crystallographic level, but it must be complete enough to permit the prediction of one test result from the results of other tests.

Correlation of Test Results: The most obvious basis for correlating different test results is that fracture occurs at the same strain for the same local conditions of stress state, etc., regardless of the conditions present in neighboring regions. Such a correlation would be feasible for conditions where fracture begins at a free surface. However, notch bend tests and notch tensile tests indicate that, under certain circumstances, fracture begins below the surface. For such subsurface crack initiation, test result correlation on the foregoing basis appears rather difficult, because the stress conditions below the surface are hard to determine, and also because it is hard to determine the exact location of crack initiation.

A more practical, though less scientific, basis for test correlation has been suggested. This suggestion is based on the hypothesis that a particular elastic stress distribution will be transformed by plastic flow into a particular strain distribution and a particular triaxiality distribution, regardless of the conditions of geometry and loading which caused that elastic stress distribution. This hypothesis is reasonable and, if true, would permit comparison between test results and engineering performance without knowledge of the local conditions at the place where fracture begins, but only of the more easily measured surface strains.

Comparing Tests and Performance: A notched test specimen can be devised having an elastic stress distribution essentially the same as a manufactured part, as determined by photoelasticity. The test specimen fails when the surface strain reaches a certain measured value, corresponding to some smaller ductility value below the root of the notch, where triaxiality has caused failure. In the manufactured part, the same triaxiality should cause failure at the same ductility and at the same distance below the surface. Because the neighboring strain distribution is the same as in the test specimen, the manufactured part also has the same surface strain at fracture as the measured value from the test specimen. This surface strain can be converted to load-carrying capacity by means of a model test.

Regardless of what basis is found ultimately to be suitable for relating different tests to each other, one requirement for the efforts of the immediate future seems clear. It is imperative to make more kinds of tests on a few materials, so as to understand the tests better, rather than accepting the value of some given test on faith, and making tests only of this kind on a great variety of materials. Any serious efforts to compare different tests in terms of some basic concept will be the beginning of the development of a rational procedure for designing against fracture.

From a paper entitled "On the Applicability of Notch Tensile Test Data to Strength Criteria in Engineering Design" presented at the ASME Annual Meeting in Chicago, November, 1955.

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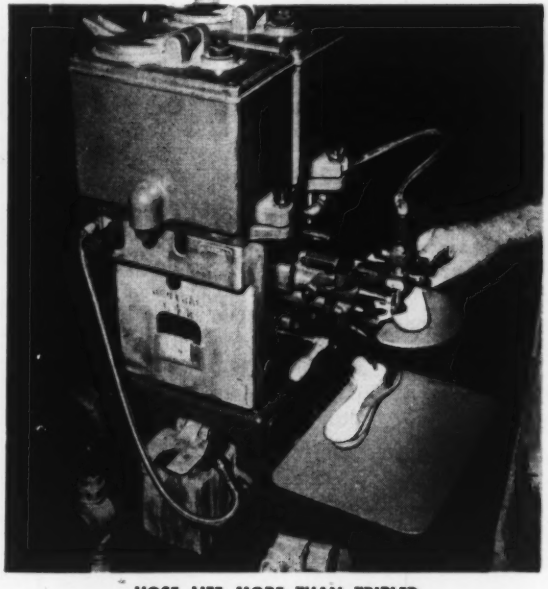

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Performance information on new series of large side indicator panel meters with bi-level scale is provided in engineering data sheet. These model 1145 meters require panel area of only 5.5 sq in. 2 pages. International Instruments Inc.

—Circle ITEM 6

Air-Line Lubricators

Air-Line lubricators described in bulletin 4169 are made in sizes for use with the smallest hand-held air tools to the largest quarry-type drills. The ½ and 1-pt size units covered are designed to prevent damage resulting from improper lubrication. 8 pages. Ingersoll-Rand Co.

—Circle ITEM 7

Magnetic Coolant Separator

Sizes, capacities and flow rates for Dings magnetic coolant separators are featured in diagram-illustrated data sheet. Sizes range from 5 to 100 gpm capacity. 2 pages. Industrial Filtration Co.

—Circle ITEM 8

Open Gear Lubricant

Bulletin 105, covering Molykote 165A and Loex lubricants, has been revised to include test data which compares 165X with conventional open-gear lubricants in terms of frictional torque versus jaw load. Loex is lithium base lubricant with −100 to 250° F range. 2 pages. Alpha Molykote Corp.

—Circle ITEM 9

Batch Weighing Machines

Weighing machines for semiautomatic packaging, bagging, batching, compounding and feeding of chemicals, pharmaceuticals, plastic powders, powdered metals, granular materials and food products are descriptively covered in form 3302. Hopper capacities of machines are 1¼ and 3 cu ft. 4 pages. Exact Weight Scale Co.

—Circle ITEM 10

Elapsed Time Indicator

Features and schematics relative to 3½-in. series HD-654 elapsed time indicator for use in registering operating times of equipment are given in bulletin MHD-155. Reverse side describes 2½-in. multiple scale instrument. 2 pages. DeJUR-Amsco Corp.

—Circle ITEM 11

Company Story

"The Reliable Story" is title of brochure which relates the development and activities of this precision spring making firm. Facilities for producing compression, extension, flat coil and torsion springs as well as many ring, coil and small wire assemblies are pictured. 24 pages. Reliable Spring & Wire Forms Co.

—Circle ITEM 12

Resistors & Controls

Covered in catalog No. 55 on resistors, controls and resistance devices are asortments of wire-wound resistors mounted on cards; fuse-type resistors for protecting TV components; deposited carbon precision resistors; and industrial and precision controls for laboratory and instrument use. Clarostat Mfg. Co.

—Circle ITEM 13

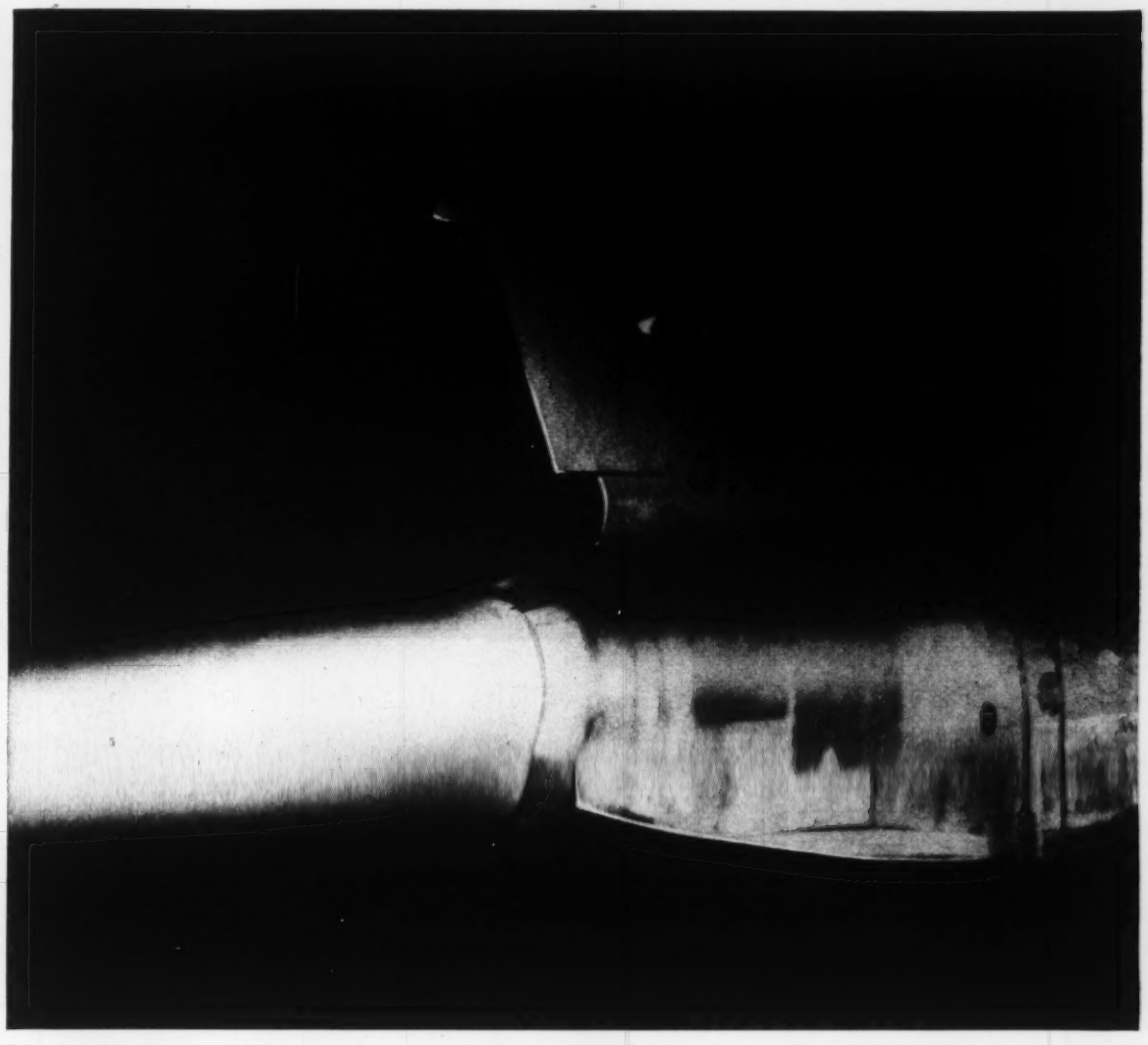
Stainless Heat Exchangers

Styles, sizes, dimensions, weights and materials of construction used in special-design stainless steel heat exchangers are given in illustrated catalog 1155. Type SSF units are used to heat or cool liquids and gases in many processing industries. 4 pages. Young Radiator Co.

—Circle ITEM 14

Graphic Engineering

Ability to understand the new, the complex and the highly technical and the ability to graphically interpret,



Tail section of North American F-100

vacuum-melted metals for "hotter" engines...

Vacuum-melted metals are breaking the "thermal-metal-barrier" of jet engine design. For they make possible higher engine operating temperatures, under conditions where conventional alloys fail rapidly.

Turbine blades of vacuum-melted superalloy, for example, were tested together with comparable blades of air-melted alloy. After 40 hours of operation the air-melted blades broke when bent less than 90° . . . the vacuum-melted blades took a full 180° bend without failure! For main shaft ball bearings, too, vacuum-melted metals far outperform conventional alloys.

Here's why . . . VACUUM MELTING LITERALLY SUCKS GASEOUS IMPURITIES FROM THE MOLTEN METAL...REMOVES INCLUSIONS AND GASSES THAT LIMIT THE PERFORMANCE OF CONVENTIONAL AIR-MELTED ALLOYS. RESULT: PURER METALS WITH EXCEPTIONAL PROPERTIES . . . LONGITUDINAL AND TRANSVERSE UNIFORMITY . . . HIGHER CREEP AND STRESS RUPTURE STRENGTH...BETTER DUCTILITY AND FATIGUE STRENGTH.

Vacuum Metals Corporation, pioneer in the development and production of vacuum-melted and cast alloys, is producing these unique new metals designed for a wide variety of aircraft applications. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

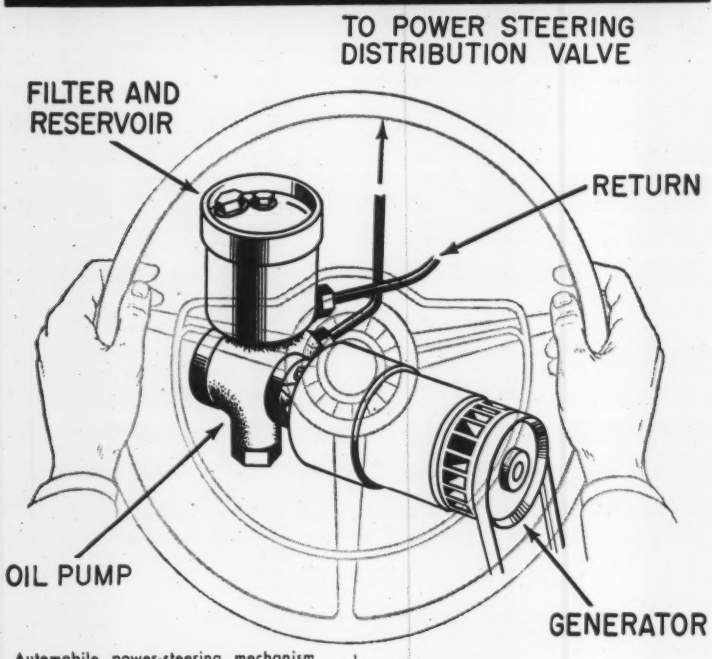
VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

—ITEM 221—

FILTER FORUM

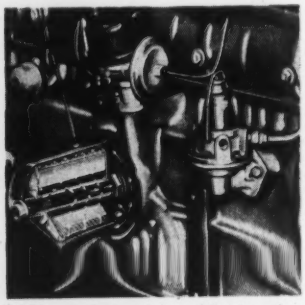


Automobile power-steering mechanism uses the filter case as a reservoir for the hydraulic oil supply.

Question:

What do you gain by including filters in original designs?

When installed equipment will not operate satisfactorily without filtration . . . or when cost savings and improved performance seem possible . . . filters can be added as an afterthought. But will foresight at the *planning* stage pay off in extra benefits?



Oil filter pad-mounted on side of engine crankcase.

PUROLATOR

FIRST in the field of filtering

Answer:

Economy, space, accessibility, better performance

Although it is certainly good engineering practice to put in a filter as soon as the need shows up, the benefits of anticipating that need are considerable:

1. A preplanned filter installation can cost less through simplification of required connections; through partial or total elimination of the filter case; or through utilization of the filter case for dual functions as in the example in our illustration.
2. Economical use of space and the job of "fitting things in" is more productive of good design in the plans stage.
3. Preplanning provides accessibility for servicing the filter and reaching other parts of the unit which might be blocked by an on-the-job filter installation.
4. Operating characteristics, i.e., the problem of pressure drop vs. flow characteristics can be balanced more effectively in the design phase.

MAIL COUPON FOR DESIGN INFORMATION

Dept. D9-28, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following filter information:

_____ Purolator's new "Filtration Manual for Designers". I'm enclosing 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

—ITEM 222—

Helpful Literature

describe and explain are requirements of "graphic engineering," subject of brochure "A Voice for Technology." Company service in organizing and arranging a technical publication is described. Personnel qualifications and facilities are detailed. 12 pages. Robert B. Warman, Inc.

—Circle ITEM 15

Control & Indicating Switches

Line of Unimax precision switches for control and indicating circuits is subject of illustrated catalog 655. Specifications, design features and dimensions for general purpose, high sensitivity, open-blade, direct current, metal case and other type units are given. 24 pages. W. L. Maxon Corp., Unimax Div.

—Circle ITEM 16

Twice As Heavy As Steel

High density Fansteel 77 metal, a machinable tungsten - copper - nickel alloy that is twice as heavy as steel, is subject of illustrated booklet F-1054. Metal is used for counterweights, rotors, flywheels, governors and vibration dampeners. Properties, manufacturing processes and other data are given. 16 pages. Fansteel Metallurgical Corp.

—Circle ITEM 17

Fluorocarbon Plastic Uses

"Inside U.S.G." is a brochure that uses word and picture to show how this company functions as a supplier of fluorocarbon plastics for many mechanical, electronic and chemical resistant purposes. It fabricates Teflon, Kel-F, Bakelite Fluorothene and others. 20 pages. United States Gasket Co.

—Circle ITEM 18

Brake for AC Motors

How the type D Unibrake brings an AC motor to a rolling stop electrically, with no wear, is told in data folder. Cut-away view shows construction features of the dynamic braking unit. Brake windings are built into the motor and give uniform braking action every time. 4 pages. Master Electric Co.

—Circle ITEM 19

Plastic Pipe Fittings

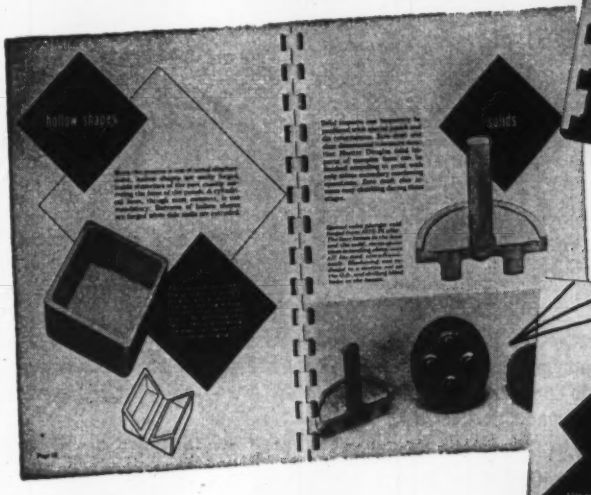
Industrial applications of unplasticized polyvinyl chloride pipe fittings, flanges and piping are discussed in illustrated booklet TTP-

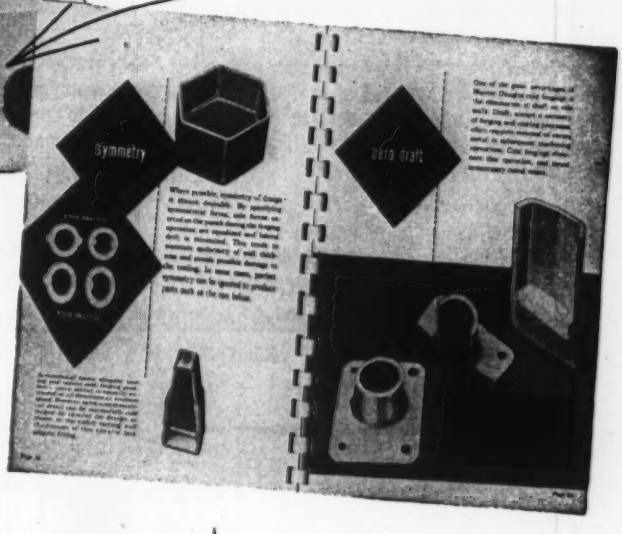
This Booklet tells

HOW TO DESIGN

for Hunter Douglas Aluminum

COLD FORGINGS & IMPACT EXTRUSIONS





If you want to sparkle with new and refreshing approaches to many design and manufacturing problems you'll want this Hunter Douglas book... just off the press! It outlines basic principles of aluminum cold forging and impact extruding, tells what types of parts can be formed and gives examples of the wide range of part geometry possible with this advanced process!

Written for Designers

This booklet will suggest many exciting advantages over conventional manufacturing procedures, *saving costs* on both tooling and production. Shows how *complex shapes* can be formed instantly to *precision tolerances*, frequently *without need for subsequent machining!* Tells why you get *stronger parts free from porosity* and how many *multi-piece assemblies can be reduced to one-piece cold forgings!* If your production potential equals 10,000 or more units per month Hunter Douglas cold forgings will be of interest to you!

Sent without cost to qualified persons engaged in engineering and purchasing. Booklets are limited to requests made on company letterheads!

Hunter Douglas Corporation

HUNTER DOUGLAS CORPORATION, DEPT MD-2, RIVERSIDE, CALIFORNIA TELEPHONE: OVerland 3-3030

Your Engineer is Right!

Investment Casting permits new approaches to design and production engineering, unbound by the restrictions of traditional metallurgical practices and manufacturing techniques.

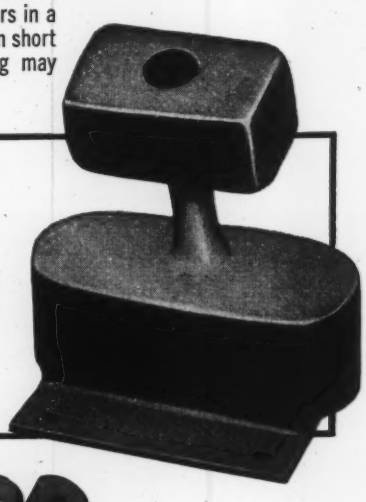
Major economies are obtained when your products or components are designed . . . or redesigned . . . with tolerance, surface and inspection criteria to conform with casting techniques. The resultant savings in final cost and production time, more than repay this small investment.

Your design engineer deserves and requires the great flexibility and latitude in design and production planning offered by Investment Casting. If application requirements demand that a part be of complex shape, intricate contours in a material that's difficult to form or machine, in short or long run quantities, Investment Casting may provide the economical answer.

CASE IN POINT!

Freedom of Design

The rudder over-balance eliminator used on the jet bomber is an investment casting of specification QQ-M-55 Magnesium, Alloy AZ-92. This intricate design is more economically produced by investment casting than any other process, permitting design freedom and assuring quality performance.



ARWOOD

ARWOOD PRECISION CASTING CORPORATION

78 Washington Street • Brooklyn 1, New York

Plants: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.

"PIONEERS IN INVESTMENT CASTING"

—ITEM 223—

Helpful Literature

119. Specifications for normal and high impact grades of threaded and socket type fittings and flanges are given, along with other technical data. 12 pages. Tube Turns Plastics, Inc.

—Circle ITEM 20

Small Switches & Their Uses

Technical data on 4MA and 5MA pushbutton actuators for industrial devices are found in 2-page data sheet P99. Plastic encased appliance switches featuring small size and high capacity are subject of 2-page data sheet 106. Also offered is 4-page publication "Uses Unlimited," on new Micro switch applications, issued "every now and then." Minneapolis-Honeywell Regulator Co., Micro Switch Div.

—Circle ITEM 21

Industrial V-8 Engine

Forty pictures, charts, drawings and diagrams are used in this bulletin on H540 and H844 V-8 engines to illustrate design, performance and economy of these two industrial engines. Operation is on gasoline, natural or LP gas. They are rated at 190 and 285 hp. 8 pages. Westinghouse Air Brake Co., Le Roi Div.

—Circle ITEM 22

Shaded Pole Motors

Details of 6-pole, 1050-rpm shaded-pole motors for air conditioning and air moving uses are found in illustrated catalog. Ratings are 1/35 to ¼-hp. Featured are Formvar insulated wire windings, Al-Spun aluminum rotor cage, widely spaced bearings and resilient ring mounting. 4 pages. Lamb Electric Co.

—Circle ITEM 23

Rubber Lattice Mountings

Problems of low frequency, high amplitude vibrations in heavy industrial machinery can be solved by use of bonded rubber lattice mountings, described and illustrated in bulletin 701. Various sizes have ¼ to 1½-in. static deflection and 250 to 3000-lb capacities per mounting. 4 pages. Lord Mfg. Co.

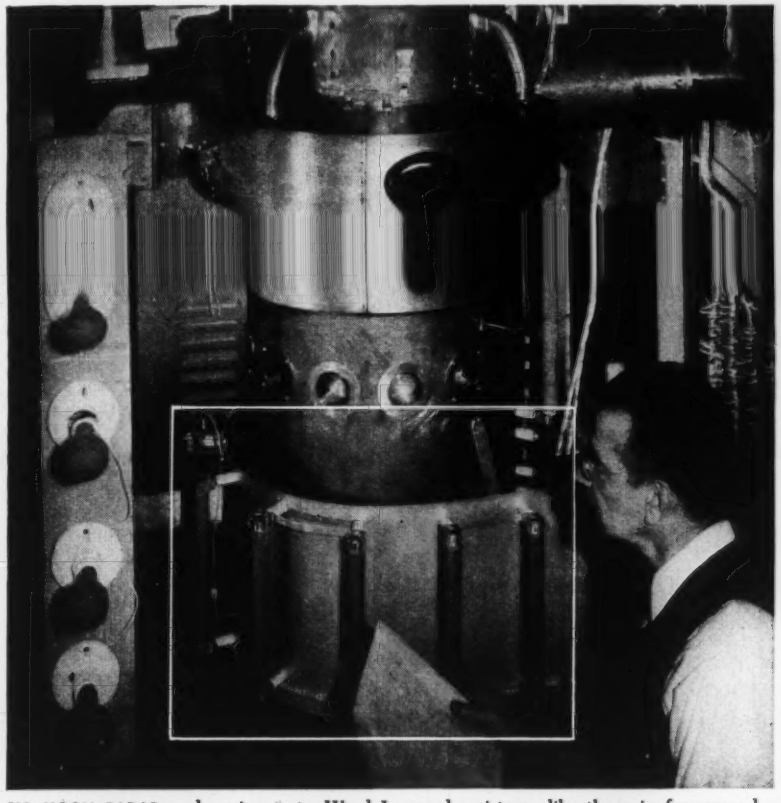
—Circle ITEM 24

Free-Machining Steel

Fatigue-Proof is name of a high strength, wear-resisting free-machining steel bar, described in illustrated brochure. Tables give chemical and physical properties and a chart com-

★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components



BIG MOON RADAR undergoing tests. Ward Leonard resistors—like those in foreground—help this gear stay on the air—or, rather, on space.

New moon radar to explore outer space

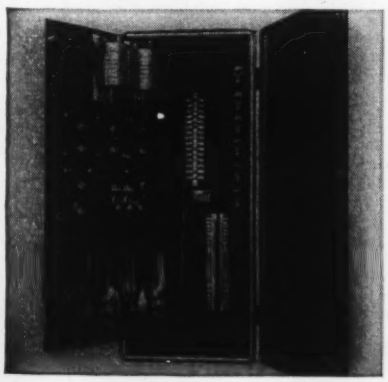
The U.S. Army Signal Corps hasn't got a transmitter in outer space—yet.

So, for their continuing studies of radio wave propagation in space and the upper atmosphere, they bounce radio waves from their new high-powered radar, Diana, off the moon and planets and study the return pulse.

Designed and built by Radio Engineering Laboratories of Long Island City, N. Y., the new radar transmitter puts out 50 kilowatts, continuous wave, and may be pulse modulated at various pulse widths and repetition rates. Receiver gain is 170-db at better than 3-db noise figure.

Throughout the equipment, high-stability Ward Leonard resistors, like the big Vitrohm resistors shown above, do duty as high-voltage bleeders, surge and current limiting resistors, and protective meter shunts in high-voltage circuits.

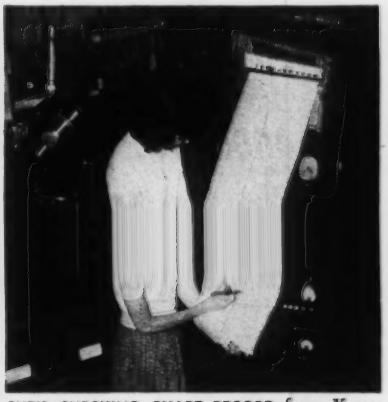
You'll find Ward Leonard Vitrohm resistors completely described in our 64-page Catalog No. 15, together with nomographs and charts to help select them. Write for your copy today.



Relays mastermind traffic lights

Sun, rain, sleet, snow, and continuous 24-hour-a-day duty is the lot of this master traffic light controller. Four dependable Ward Leonard relays select automatic timing cycles. Two more relays allow remote control of off-duty flashing amber signals and signal shut-down. Learn more about these rugged relays in Ward Leonard Bulletin No. 110.

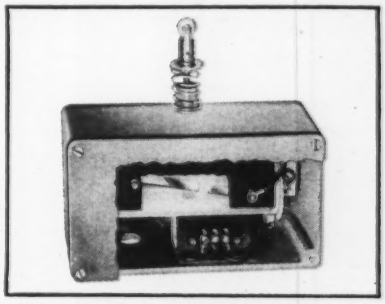
Photo courtesy Crouse-Hinds Co.



SHE'S CHECKING CHART RECORD from X-ray spectrometer in Ward Leonard's test lab.

Plant X-ray speeds quality control and helps catch crooks

X-ray diffractometer and spectrometer tests insure high quality and uniformity of both raw materials and fabricated components at Ward Leonard. These instruments check crystal structure in ceramics, magnetic amplifier cores, contact metal, and resistance wire. In off hours, they help the Mount Vernon Police and Fire Department put the finger on crooks and arsonists.



AUTOMATION FOR MACHINE TOOLS is simplified by this precision control potentiometer.

Control for machine tools

Accurate electronic control component for cutting tools, winders and processing machine drives is provided by this compact, precision potentiometer.

A half-inch plunger movement drives the metal alloy contact across the special resistance element. Enclosure is compact; calibration is permanent. Standard resistance—10,000 ohms; up to 25,000 ohms on special order. Write for Bulletin 68. 63

WARD LEONARD ELECTRIC COMPANY

58 SOUTH ST., MOUNT VERNON, N. Y.

Result-Engineered Controls Since 1892

RESISTORS · RHEOSTATS · RELAYS · CONTROLS · DIMMERS

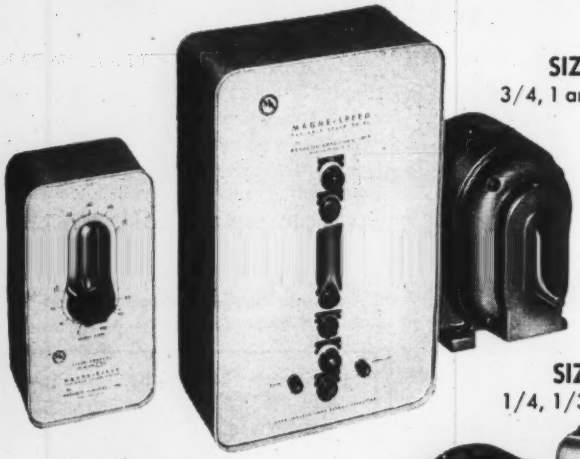
AFFILIATE OF GENERAL CERAMICS CORPORATION

Magnetic Amplifiers · INC

—announces its new

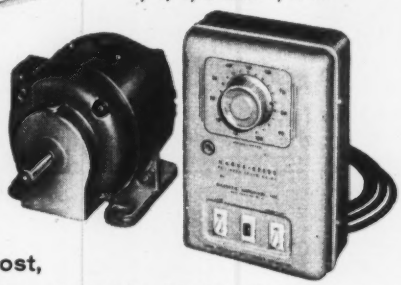
VARIABLE SPEED DRIVE

MAGNE-SPEED*



SIZE II —
3/4, 1 and 1-1/2 HP

SIZE I —
1/4, 1/3 and 1/2 HP



Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

Other MA Products and Services

Magnetic Servo Amplifiers
Transi-Mag * Amplifiers
Analog Computors
Photoelectric Controls
DC and AC Regulated Power Supplies

* Trade Name

Application engineering and conversion of tool machines and production processes to automatic control.

Magnetic Amplifiers • Inc
Tel. CYpress 2-6610 • 632 TINTON AVE., NEW YORK 55, N. Y.

Helpful Literature

pares its properties with those of carbon and alloy heat treated bars and parts. 20 pages. La Salle Steel Co.

—Circle ITEM 25

Motors & Generators

Construction features of high speed synchronous motors and generators are found in 6-page bulletin SB-154. Motors range from 1/20 to 2500 hp and generators from ½ to 2000 kw. Also available is 4-page folder SB 157 on explosionproof motors in frames from 56 to 680. Design details of the 1/12 to 250-hp motors are given. Marathon Electric Mfg. Corp.

—Circle ITEM 26

Aluminum Hand Forgings

Minimum mechanical properties of all classes of aluminum hand forgings produced by this company are charted in this folder, designed for wall chart, file folder or notebook use. Forgings made from 2014-T6 and 7075-T5 alloys in sizes up to 2000 lb are tabulated. 6 pages.

Kaiser Aluminum & Chemical Corp.

—Circle ITEM 27

Products of Plastics

"How the Nosco Plant Works to Produce Your Needs in Practical Plastics" is an illustrated brochure which describes the company's 227,000 sq ft plant and its facilities. Case histories of difficult and unusual molding jobs that have been solved for customers are included. 12 pages. Nosco Plastics, Inc.

—Circle ITEM 28

Flexible Metal Hose Data

Use and application data on Universal flexible metal hose products are contained in design engineering reference manual U-333. Hose is offered in range of materials and in types to compensate for such conditions as varied pressure, elevated temperature, motion and vibration. Universal Metal Hose Co.

—Circle ITEM 29

Magnetic Conveyors

Space Saver magnetic conveyors which handle ferrous parts and pieces up inclines as steep as 90 degrees without need for belt cleats are described in illustrated bulletin MC-250. They feed machines, stack parts and perform parts turn-over. Specifications are included. 8 pages. Homer Mfg. Co.

—Circle ITEM 30

Users of tubing for cylinder applications now you can have this new...

J&L Cold Drawn ELECTRICWELD

Tubing with a [redacted] ID Finish

Reduces your overall production costs in applications like these . . .

- **cylinder tubing**
- **hydraulic and pressure tubing**
- **shock absorbers**
- **ordnance components**

This new drawn-over-mandrel grade tubing with its mirror-like inside surface finish is today busy helping manufacturers reduce or entirely eliminate costly machining on many applications and is being substituted for more costly types of steel tubing. For example, it may be used, without inside honing, for many cylinders through which plungers are passed.

J&L Cold Drawn ELECTRICWELD Tubing with a *Special Smooth* ID finish combines the physical advantages imparted by today's modern electric welding techniques with those of cold working. It withstands high internal hydrostatic pressures, carries heavy torsion loads, resists high-frequency vibration, and offers a favorable weight-to-strength ratio for applications in which loading occurs in all directions.

J&L Cold Drawn ELECTRICWELD Tubing can be furnished in its three specifications in OD sizes from ¾-inch to 2¼ inches and in wall thickness from 20 to 10 gage, 0.035 and 0.134-inch respectively.

This new booklet provides the information you need . . . specifications . . . tolerances . . . chemistry . . . mechanical properties . . . annealing . . . finishes.

Send for your free copy today!

J&L STEEL

Jones & Laughlin Steel Corporation
Dept. 410, 3 Gateway Center, Pittsburgh 30, Pa.

Send me a copy of your new Gold Drawn ELECTRICWELD Booklet.

Name_____

Title_____

Company_____

City_____ Zone____ State_____

—ITEM 226—

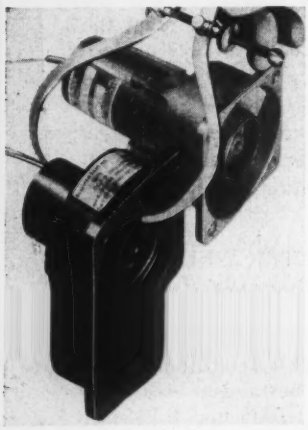
NEW PARTS AND MATERIALS

Use Yellow Card, page 19, to obtain further information

Subminiature Blower

for variable-frequency power systems

When input-power frequency of type SC blower is varied from 320 to 1000 cps, air flow varies between 42 and 30 cfm and rotational speed changes from 14,000 to 10,000 rpm. Frequency range can be extended to 1400 cps if reduction in air flow to 18 cfm is permissible. Designed for single-phase systems, the blower has an input power range from 21.5 to 28 w. Weight is only 5 oz and the unit



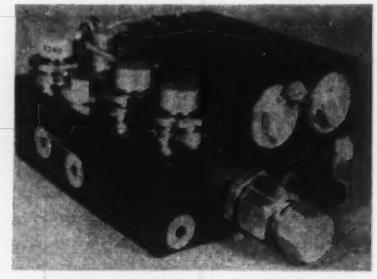
measures 2¼ in. long. Special bearings may be specified for operation under high ambient temperatures. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, O.

—Circle ITEM 61

Solenoid Valve

is packaged unit with seven integral components

Four-way, closed-center, solenoid valve incorporates in the same housing: restrictor and by-pass valve, pressure-relief valve, two thermal-relief valves, pressure switch, check valve, and solenoid-operated shut-off valve. Designed



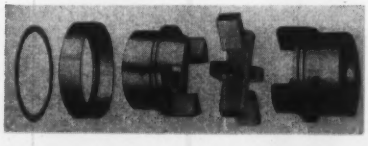
for use in oil-hydraulic systems employing on-off servomechanism control, it is particularly suited for installations requiring two-way actuation of controls at two different rates of response. Valve operating pressure limit is 4500 psi at air temperatures up to 350 F. System fluid temperature limits are 300 F and 400 F at inlet and return ports, respectively. Electrical input to solenoid is 28 v dc. **Vickers Inc.**, 1400 Oakman Blvd., Detroit 32, Mich.

—Circle ITEM 62

Flexible Coupling

is easily removed in radial direction

Flexible coupling designated model C-R is suitable where assembly and disassembly of coupling must be accomplished in radial direction. Cushions held in place by C-type collar are easily removed with coliar, allowing the coupling half which is connected to the shaft to



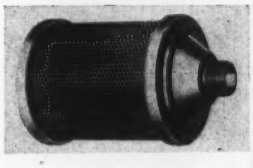
be rotated until the intermeshing jaws slide into the stationary coupling half. No lubrication is required, and six sizes rated from 2.58 to 29.6 hp at 100 rpm are available. Cushions are reversible, doubling their service life under unidirectional loading. **Lovejoy Flexible Coupling Co.**, 4818 W. Lake St., Chicago 44, Ill.

—Circle ITEM 63

Noise Attenuator

for air-operated equipment

Internal resonator and high-flow diffuser of 4-44 series noise attenuator eliminates most of the ob-



jectionable exhaust noise of air-operated equipment. Available in eight pipe sizes from ⅛-in. to 2 in. NPT, unit is sturdily built. Male pipe thread is provided for direct connection to equipment exhaust port. **Allied Witan Co.**, P. O. Box 2770, Cleveland 11, O.

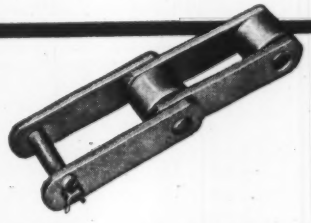
—Circle ITEM 64

Power Transformer

has 93 per cent efficiency

Wye-to-delta GC150 power transformer converts three-phase ac from 200 v to 115 v, line-to-line. Designed to MIL-T-9219, it offers guaranteed 93 per cent efficiency (25 C ambient) and 4 per cent regulation at rated load. Housed in an aluminum case, the transformer withstands extremes of humidity, fungus, corrosion, and vibration. Neutral point of the primary wind-

For longer chain life, here's
less bushing and joint wear



Large-diameter rollers of Link-Belt SS chains reduce chain-pull due to frictional resistance.

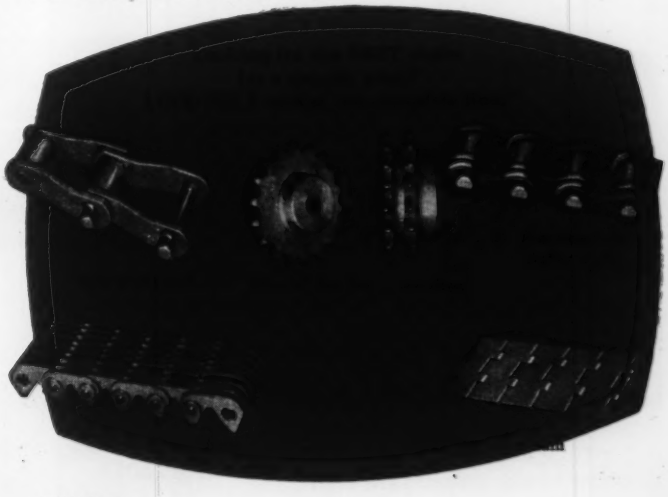
LINK-BELT SS roller chains are designed for abrasive, heavy-duty service

FOR hard-working drives and conveyors, choose Link-Belt SS bushed roller chain. Its hardened steel joint assures longer life in gritty and abrasive applications. Accurately machined parts provide a firm, tight fit of pins and bushings in the steel sidebars. In addition, accurate control of raw material specifications and manufacturing processes results in uniformity . . . longer life.

Whatever your particular chain requirements in regard to speed, weight of loads or severity of service—the completeness of the Link-Belt line will provide the right answer. No other manufacturer offers such a broad range of silent and roller chains—of cast, combination, forged and fabricated types. And a complete selection of attachments permits efficient adaptation to varied services.

For help with any chain problem—big or small—call your local Link-Belt office. They are qualified to make an unbiased recommendation of the one chain best-suited to your exact needs.

Link-Belt Class SS roller chain assures steady, even flow of fabricated products from medium-temperature industrial oven manufactured by The W. W. Sly Manufacturing Co., Cleveland, Ohio. Link-Belt precision steel roller chain and roller bearing blocks are also used.

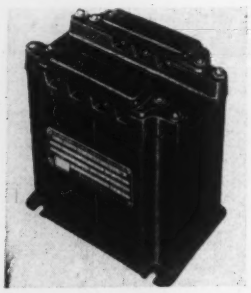


LINK-BELT

THE SYMBOL OF QUALITY — LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,889-A



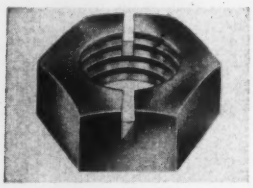
ings is isolated from the case and brought out to a separate terminal. Frequency is 380 to 440 cps. Five-minute rating is 2.25 kva and one-minute rating is 3.75 kva at 0.8 power factors. **Jack & Heintz Inc.,** 17600 Broadway, Cleveland 1, O.

—Circle ITEM 65

Free-Running Locknut

locks when seated

The upper portion of this one-piece, free-spinning locknut is slotted, and the bottom face is undercut. When the nut is tightened, the threaded upper segments move in-



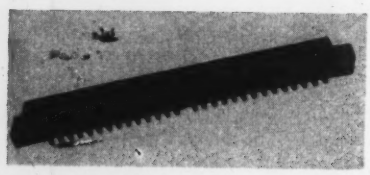
ward and produce a vibration-resistant lock on the threads of the screw. Immune to the effects of both oil and water, nuts are steel, brass, aluminum or stainless and are available in all Machine Screw sizes. **Jacobson Nut Mfg. Corp.,** P. O. Box 177, Kenilworth, N. J.

—Circle ITEM 66

Printed-Circuit Receptacle

has low contact resistance

Coil-spring grip of PCSC28 receptacle for printed circuits provides

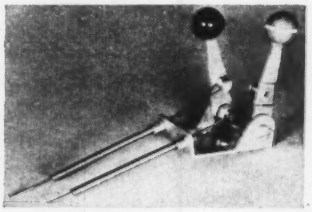


low contact resistance over entire circuit contact area, even when circuit board is undersized. Gold-plated phosphor-bronze contacts are available in single or double rows to accommodate up to 56 connections. Connector material is either mineral-filled melamine, Plaskon reinforced alkyd type 440A, or Orlon-filled diallyl phthalate molding compound. Special printed-circuit receptacle PCB20 can also be supplied to accommodate two circuit boards, each with ten connections. **DeJur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N.Y.

—Circle ITEM 67

Twin-Lever Control

for small power plants



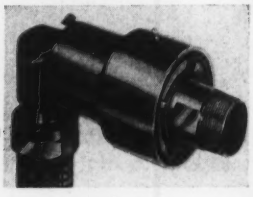
Throttle and clutch in small gasoline engine installations can be remotely operated by this twin-lever control assembly. Typical applications include power lawn mowers, motor bikes, outboard motors, and small tractors. Length of levers is 3⅛ in., and maximum travel is 1⅞ in. Control unit can be mounted either on a flat surface or on tubular members. Construction is zinc-plated steel, except for knobs which are plastic and are color coded red and black to identify function. **Arens Controls Inc.,** 2017 Greenleaf St., Evanston, Ill.

—Circle ITEM 68

Rotary Joint

has ball-bearing construction

Designed to transfer liquids or gases from stationary lines to rotating receivers, rotary joint has ball bearings to prevent shaft misalignment and to insure leak-proof operation. Type PR 25 shown is 1½ in. pipe size; standard sizes from ⅜ to 2 in. IPS are available in both siphon and single-flow



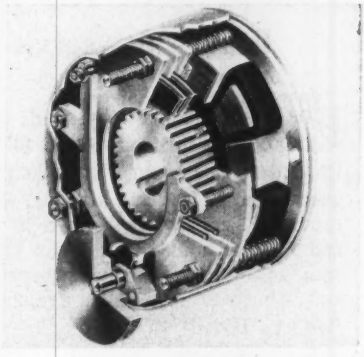
types. All models have exterior screw adjustments, floating seals, and pressure-equalizing chambers. **Seamlex Co. Inc.,** 41-23 24th St., Long Island City 1, N. Y.

—Circle ITEM 69

Electric Brake

has long-life lining

Change in air gap is only 0.0015-in. per friction surface in series E electric brake after ½-million start-stop cycles at 10 cycles per minute, manufacturer's tests show. Designed for use with one, two, or three-phase motors, the brake has a circumferential coil arrangement that is the equivalent of six E-type magnets, providing high pull-in force at large air gaps. Brake mechanism supporting studs



are supported at their outer ends by the cast-aluminum brake housing, minimizing shock-induced bending of the studs and brake misalignment. Brake linings are bonded to aluminum disks that are spline-mounted on the driveshaft to which braking action is applied. Supplied as optional equipment, the manual release is off-center to permit two-end shaft mounting. **Miehle Printing Press & Mfg. Co.,** Star-Kimble Motor Div., 200 Bloomfield Ave., Bloomfield, N. J.

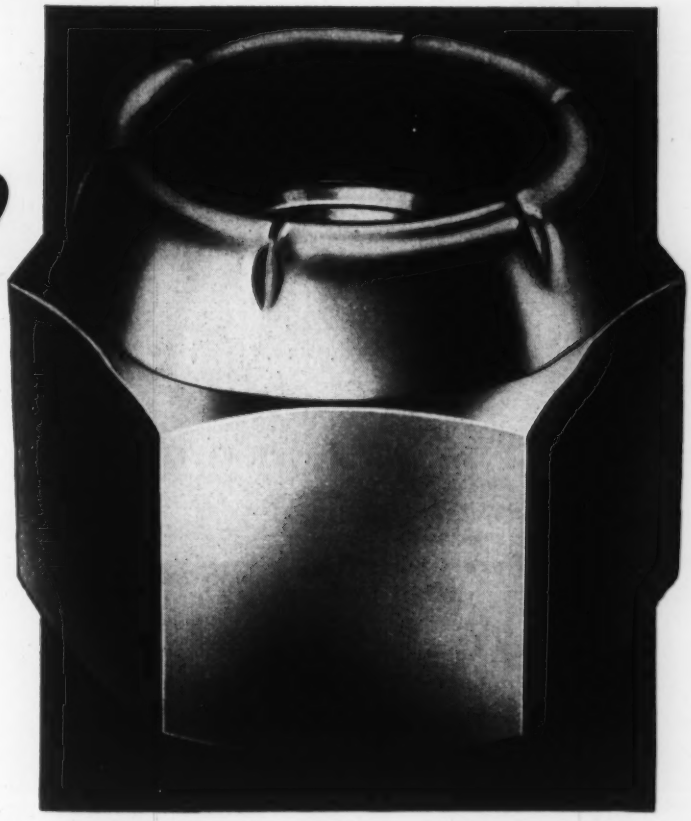
—Circle ITEM 70

Shaft Collar

available in 44 bore sizes

Line of shaft collars is designed to eliminate axial floating of shafts that are mounted in plain bearings. Precision bored and chamfered on inside and outside corners, collars are made in 44 bore diameters from 3/16-in. to 3 in. In sizes up

What's special about this STOP NUT?

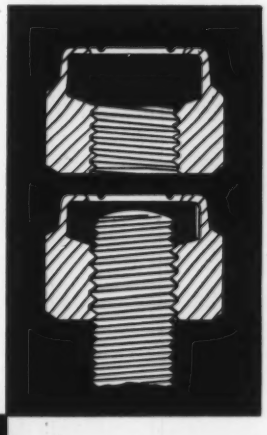


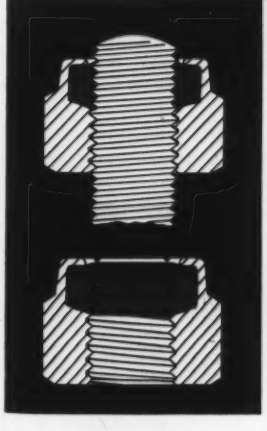
Several things make this nut unusual. For instance, you can "stop" it at any position on the threaded length of the bolt . . . or wrench it tight against the work where it protects bolt threads against corrosion and prevents liquid leakage. No matter where you leave it on the bolt, it will remain tight in that exact position, even though you subject it to heavy vibration and shock loads. But use a wrench on it and it comes off as easily as it went on. The red locking collar is nondestructive—does not gall bolt threads or remove plating. You can remove it and re-use it again and again.

What gives it its grip?

1 The locking collar is unthreaded and elastic. It has an inside diameter smaller than the major diameter of standard bolts.

2 The bolt impresses a mating thread into the collar and the resulting compressive forces exert a constant friction grip on the bolt. . . .





3 and exert a downward thrust bringing the lower flanks of the bolt thread into firm metal to metal contact with the matching nut threads, eliminating normal axial play.

4 Nut is removable and reusable . . . the Red Elastic Collar retains its grip after repeated usage.

Will it hold under ALL conditions?

The locking principle of the Elastic Stop® nut has been tested and proved by over 25 years of actual field service. Elastic Stop nuts are used on locomotives . . . and pile drivers. They fasten hedge shears and harvesters, drilling rigs and washing machines, trucks and roller skates. And no Elastic Stop nut customer has ever stopped using them because of unsatisfactory performance.

What about sizes and materials?

Elastic Stop nuts are available from a watchmaker's 0-80 all the way to 4"—in materials that include stainless steel, brass, aluminum and other alloys. Protect your product with "fastener insurance." Try Elastic Stop nuts on trouble spots, whether to protect expensive heavy equipment from costly downtime or to guarantee the accuracy of delicate electrical equipment by maintaining precision adjustments. We'll supply free test samples.

ESNA® TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. N82-24, 2330 Vauxhall Road, Union, N. J.

Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

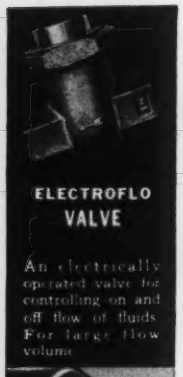
Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

—ITEM 228—

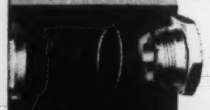


ELECTROFLO VALVE

An electrically operated valve for controlling on and off flow of fluids. For large flow volume.

SHUR-FLO INTERLOCK

A control to protect equipment when flow is below a desired minimum; or above a desired maximum.

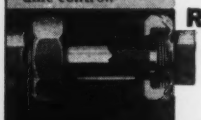


MESURFLO CONTROL

A flow volume control to deliver onset rate of fluid flow, regardless of variable inlet pressures.

ELECTRO-MITE VALVE

A direct action solenoid valve for small flow volume. Available with volume control.



STRAITFLO STRAINER

A straight line strainer, installed in the supply, having the entire strainer area within the flow way itself.

ELECTRO-MESURFLO VALVE

An electrically operated valve with flow volume control. For medium flow volume.

New

AUTOMATIC

FLOW

CONTROL *for* WATER

If your problem concerns a specified flow of fluid or time-fill, we suggest you design Hays *automatic* flow controls into your equipment. Hays products are trouble-free and offer absolute internal water control. They are low cost, and eliminate the need for such components as pressure regulators, filters, and other devices.

WRITE FOR TECHNICAL REFERENCE FOLDERS

HAYS

INDUSTRIAL SALES DIVISION

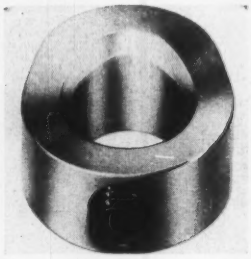
HAYS MFG. CO.

West 12th Street

ERIE, PA.

—ITEM 229—

to 2 in., they are machined cold-rolled steel, cadmium finished. Larger sizes are cast iron with



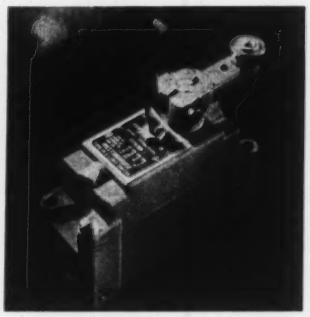
gray lacquer finish. Precision cup-point set screws are provided with the collars. **Climax Metal Products Co.**, 863 E. 140th St., Cleveland 10, O.

—Circle ITEM 71

Limit Switch

can be operated in either direction

Lever-operated type PLS limit switch can be adapted for clockwise, counterclockwise, or universal operation by turn of a se-



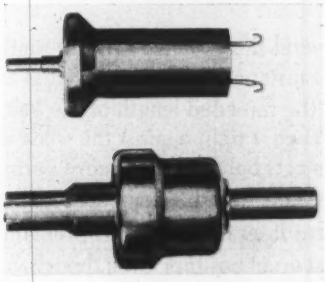
lector screw. Suitable for machine tool or general purpose use, it can be flush or projection mounted. Also available is type PRS switch, which is push-rod operated. Normal alternating current ratings of contacts in both switches range from 15 amp, 115 v to 5 amp, 600 v. Direct current ratings are from 2.0 amp, 115 v to 0.1 amp, 600 v. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

—Circle ITEM 72

Linear Actuator

is operated by solid-to-liquid phase change

Actuating force in this linear actuator is developed when enclosed substance is melted, either by an external heat source or by an internal resistance winding. In changing to liquid form, actuating substance expands and displaces the actuator ram. As unit cools, the substance solidifies and the ram is returned to its original position by a spring. Different models, all weighing only a few ounces, are available in body lengths from 3 to 4 in. Thrust-to-weight ratio is



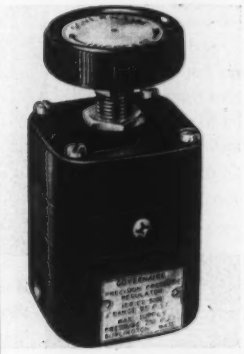
2000:1, and the smallest actuator can move a 300-lb load a distance of 1 in. Vibration tolerance is as high as 50 *g*. **Standard-Thomson Corp.**, Vandalia, O.

—Circle ITEM 73

Pressure Regulator

has negligible drift

Stability of series 5000 piloted regulator is due principally to Ni-Span C measuring capsule, which is not affected by temperature changes and has negligible hysteresis. Sub-



stantial changes in downstream pressure result from very small movements of the pilot valve (usually less than 0.0001-in.), giving high-gain control of output. Designed for pneumatic gaging applications, and for remote setting of controllers, unit is sufficiently accurate for laboratory use, since pressures are held to 0.1-per cent. It is available in 25 and 60-psi

CORNING GLASS BULLETIN FOR PRODUCT DESIGNERS

CORNING GLASS WORKS, 52-2 Crystal Street, Corning, New York

Please send me the following material:

- ☐ Booklet: "Glass and You."
- ☐ Bulletin IZ-1: "Glass . . . its increasing importance in product design."
- ☐ Information on the VYCOR brand glasses.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

How to engineer a platypus

A happy combination of purposeful practicality is the furry platypus with its webbed feet, beaver's tail, and duck's bill.

A lot of our customers, to their continuing delight and profit (we hope), have discovered that glass is sort of platypus-like in that it, too, can be made to combine many useful characteristics.

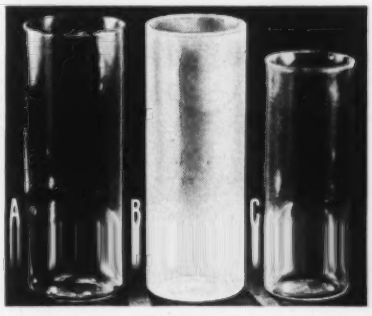
Take, for example, PYREX brand pipe. Here you see a man using a piece of it to drive a one-inch nail in a pine block. This is essentially an extra-curricular activity for glass pipe, which is more at home conveying metal-eating acids around chemical plants, but it's a way of showing just how tough glass can be when it's *made* that way.

All of which may serve to illustrate for you how we can arrange the optical, chemical, thermal, mechanical, and electrical properties of glass in different combinations to match a considerable variety of end-use requirements. In fact, we've worked up some 50,000 different formulas for glass in our years of helping customers solve specific design and processing problems.

If platypus-like glass is a novel idea to you, if you've never given glass a second thought as a highly adaptable design and construction material, we suggest your reading a pocket-size volume entitled "Glass and You." It tells in a few words and many pictures how glass contributes to profit and pleasure and we'd be delighted to send you a copy. Or, if you're more concerned with putting glass to work for you than in learning what it's doing for others, there's a slightly more technical bulletin called, "Glass—its increasing importance in product design." We'll be glad to send you either—or both.

Most remarkable glass

In 1952 Philadelphia's Franklin Institute presented the John Price Wetherill Medal to Corning's Dr. Martin E. Nordberg and Harrison P. Hood for inventing the most fabulous of glasses—VYCOR brand 96 per cent silica glasses.



Evolution of a VYCOR jar: A—formed by conventional glass blowing; B—"thirsty glass"; C—finished product.

These two scientists discovered a composition that appeared to be a combination of two distinct types of glasses. One type could be dissolved out, leaving a skeleton of 96 per cent or more of silica filled with so many millions of holes that a one-inch cube contained some 60,000 square feet of hole surface.

This new child of research was dubbed "thirsty glass" because, just sitting around, it absorbed moisture right out of the air. But our researchers were on the trail of something even more exciting. They heated their "thirsty glass" and it shrank to two-thirds its original size. The millions of little holes vanished and left a vacuum-tight glass that looked like any other—except that you could take this new glass white-hot from a blazing furnace and plunge it into ice water without the slightest injury. It was a glass as ideal as fused quartz, but different since it could be melted, mass produced, and worked in its original state like ordinary glass.

If you'd like to know more, just check the coupon above.

Ribbon glass by the yard

Here's a glass that's a thousandth of an inch thin and in small widths it's flexible as—well, a ribbon. You can twist it, roll it, wrap it around your arm without cracking it. It comes in any length you want—inches, yards, miles.

Actually ribbon glass isn't a single glass. We can make it of several different compositions according to what you need it for. Originally we developed it to take the place of mica in electronic capacitors of which there are several in your radio and TV sets and in any other piece of electronic equipment you can name. As mica is formed in layers, it is subject to cleavage in the plane parallel to lamination; ribbon glass being homogenous is easily workable. This is just one advantage of this glass in capacitors.

Medical scientists have found a quite different use for ribbon glass—as microscope slide covers. These are the wafer-like pieces of glass that are used to cover blood smears and the like for examination under the microscope. In this case ribbon glass can be made clearer, flatter and more free of bubbles and striae than previously made glasses.

Seems as if this unique stuff should be good for a *lot* of things, but *what* (other than electrical and laboratorial) probably lies in the laps of imaginative designers. Would you like us to send you a little strip to play with? *Customer* ideas and problems really bring out the best in glass. So, even if what's on your mind seems unrelated to any item this page discusses, glass may still be its fulfillment. We'd like to hear from you.

CORNING GLASS WORKS

CORNING, N. Y.

Corning means research in Glass

Compact new Gast rotary
No. 6 Air Motor delivers

TWO HORSEPOWER

. . . weighs only 17 pounds

Here's compact, light-weight power—offering many advantages as original equipment on your products! With the new 2 h.p. Model 6AM added to the line, Gast offers rotary air motors in five popular sizes from the 1/20 h.p. Model 1AM to the 4 h.p. Model 8AM.

To fulfill designers' needs, Gast also offers standard variations on some models, including foot or flange mountings for vertical or horizontal applications with direct or gear drive . . . special reversible rotation, etc. Well adapted for plant use or as original components, Gast Rotaries are *explosion-proof, variable in speed, burn-out proof* even when stalled—and low in first cost!

Wherever compressed air is available, they're a power source worth investigating! *Write for Model 6AM Bulletin 855*—or specify size that interests you. *Request "Application Ideas" Booklet too!* — Gast Manufacturing Corp., P.O. Box 117-P Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

—ITEM 231—

New Parts

ranges for pipe sizes ⅛ and ¼-in. Body dimension is approximately 2 in. across flat surfaces, and flow capacity is 6 cfm. **Bellofram Corp.**, Governaire Div., Burlington, Mass.

—Circle ITEM 74

Pressure Transducer

measures both absolute and differential pressures

Multipurpose pressure transducer, containing two independent diaphragm - potentiometer systems, measures both absolute and differential pressures. Instrument link-

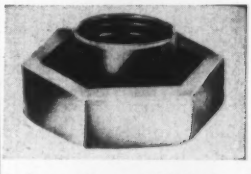
ages are dynamically balanced and easily adjusted. The unit withstands abnormal pressures and severe environmental vibrations. Unitized construction facilitates calibration and repair. Various resistance values with either linear or functional outputs are available. Transducer is suitable for measurement and control of fuel pressures, hydraulic flow, and similar industrial and aircraft applications. **Fairchild Controls Corp., Components Div.**, 225 Park Ave., Hicksville, N. Y.

—Circle ITEM 75

Self-Locking Nut

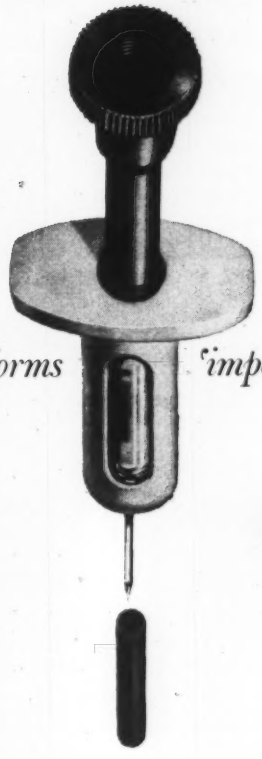
gives uniform locking torque from −100 F to 550 F

Locking action of Kaylock metal hex nut is provided by upper



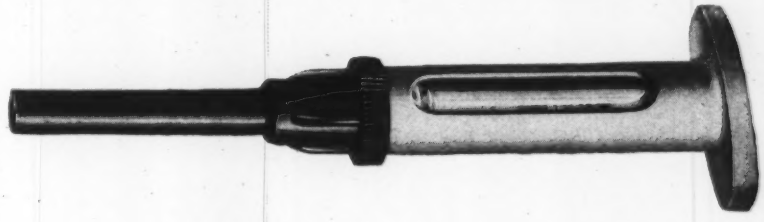
threaded portion, which is elliptically deformed. Designated series H10, nuts provide uniform locking torques through ambient-tempera-

—ITEM 231—
For More Information Circle Item Number on Yellow Card—page 19



NOSCO 'CAN DO'

transforms 'impossible' parts into another everyday molding job



A noted pharmaceutical company asked us to develop an expendable hypodermic syringe that would remain completely sterile until use. Nosco engineers put their heads together . . . and came up with the answer pictured above! It looks simple—but here are a few of the tricky design problems involved.

There were dissimilar female threads at the ends of the combination needle guard and plunger . . . so we matched the pitch of these threads to enable the part to unscrew and eject as our mold is opening.

The syringe flange must be rigid to resist finger pressure when the hypo is administered, but it must also be undercut to hold the vial firmly in place. So, together with a material supplier, we developed a filled polyethylene to satisfy this part. And we solved the difficult task of removing the core pins from the syringe through the narrower top opening, by using floating pins temporarily held firm when the mold is first opened.

Despite these technical problems, the first volume order of Nosco-molded syringes were delivered to our customer on schedule.

Like our pharmaceutical customer, you'll be pleasantly surprised when Nosco "Can Do" goes to work for you! Let one of our sales-engineers start Nosco "Can Do" designing your next plastic part.

NOSCO plastics, inc. • erie 2, pa.

World's largest injection molding plant

For other case histories—and a glimpse of the Nosco plant and facilities, send for the free 12-page brochure.

Nosco Plastics, Inc., Erie 2, Pa. Send . . . copies of brochure: "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY _____ STATE _____

—ITEM 232—

XUM

For those
TOUGH SPRING
APPLICATIONS
(High Temperatures . . . Corrosive Service
. . . Low Temperatures)

Use
ALLOY Wire...Rod...Strip

Spring Designers: You can readily select a material with just the right combination of properties for your tough spring applications from the alloys we fabricate into wire, rod and strip. Alloys such as Monel, K Monel, Inconel, Inconel X, Nickel, Duranickel, Austenitic, Ferritic and Martensitic Stainless Steels and special alloys are available in a wide range of tempers and special treatments. These materials feature high strength and fatigue properties at elevated temperatures, good ductility at sub-zero temperatures, low magnetic permeability and excellent resistance to a wide variety of corrosive conditions.

Alloy Metal Wire Division engineers will work closely with you to develop any special engineering and fabricating properties you may require. Your inquiries are always welcome.

Send today for our new
Nickel Alloy and Stainless Steel
Properties Charts.

ALLOY METAL WIRE DIVISION

HKP
H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

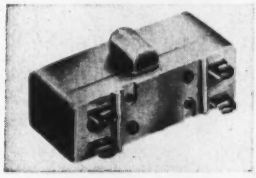
—ITEM 233—

ture range from −100 F to 550 F. Low overall height allows use of short thread length on bolts. Requirements of AN363, AN364, and AN365 are satisfied, and thread sizes 4-40 to 5/16-24 are available. **Kaynar Co.**, Kaylock Div., 820 E. 16th St., Los Angeles, Calif.

—Circle ITEM 76

Small Switch

has high current capacity



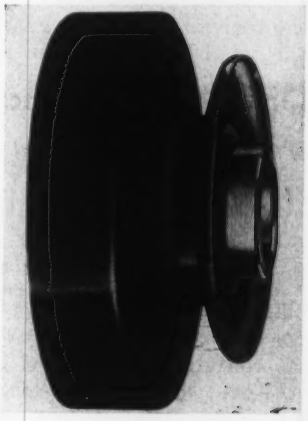
This 40-amp switch, measuring 1¾ x 43/64 x 43/64-in., is capable of handling large current ratings. Rating is 40 amp at 125/250 v ac or 30 v dc resistive. Construction combines the double-break characteristic of the basic switch with a heavy-duty switching element. Plastic housing permits operation at high temperature and provides high shock resistance. Operating force is 30 oz, and electrical and mechanical life is 100,000 cycles. **Electro-Snap Switch & Mfg. Co.**, 4318-30 W. Lake St., Chicago 24, Ill.

—Circle ITEM 77

Automatic Clutch

for use with three sizes of fractional-horsepower motors

Designed for 1/6, ¼ and 1/3-hp electric motors, the Mercury 305 automatic clutch reduces the length of sustained inrush current by permitting the motor to reach full speed before any load is ap-



FROM *minnows* TO WHALES

This is a kind of "Mutt & Jeff" portrayal of CORNISH versatility in designing and producing any type and size of Cord Set to YOUR special needs. Leading manufacturers of electrical equipment and appliances no longer gamble... they just *CORNISH 'em!* All our technical and physical facilities at YOUR service.

BE **SURE** WITH

CORNISH

Custom **CORD SETS**

CORNISH WIRE CO., INC.

50 Church Street New York 7, N. Y.

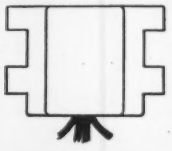
another FURNAS "FIRST"

features

- MOISTURE AND FUNGUS RESISTANT
- EXCELLENT HEAT DISSIPATION
- DIMENSIONALLY STABLE
- MECHANICALLY STRONGER
- NON-COMBUSTIBLE

Furnas Electric again leads the field. Now magnetic motor controls are available with Dual Seal coils. Dual Seal coils mean longer control life. Why? Because Dual Seal molded coils are moisture and fungus resistant, eliminating the most common cause for coil failure. These homogeneous molded coils are dimensionally stable, age resistant, will not support combustion and have high dielectric strength. Mechanical properties of Dual Seal coils eliminate damage due to vibration or impact and are impervious to damage by screwdrivers and other hand operated tools. Only Furnas magnetic controls are equipped with Dual Seal coils. Before you buy, investigate the many advantages of these controls. Then specify Furnas Electric.

DUAL VOLTAGE COILS



Furnas Electric magnetic controls with exclusive Dual Seal voltage coils are matched for use with your dual voltage motors. Coil changing is now virtually eliminated and stocking of coils and starters simplified. For example, on 3, 7½ and 10 horsepower starters, one 220-440 volt Furnas Electric coil is used where six are normally required. Simple, on-the-job, reconnection of coil leads change high to low or low to high voltage as required.

OTHER FURNAS FIRSTS

- First Drum Controller with built-in thermal overload protection.
- First small Drum Controllers for reversing and speed changing.
- First to build compact, easy to operate Master Switch for wound rotor motors.
- First Tap Switch for single handle control of rectifiers.
- First to use the principle of Switchlets for auxiliary contact on starters.
- First to build a line of in-between sizes of starters.

Write for free 140 page Furnas Electric Catalog —1045 McKee Street, Batavia, Illinois.

FURNAS

FURNAS ELECTRIC COMPANY
BATAVIA, ILLINOIS
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

—ITEM 235—

New Parts

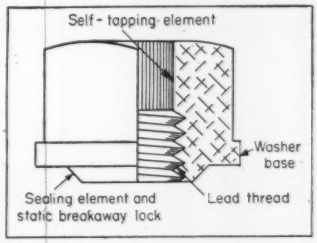
plied. In handling high inertia loads, it assures smooth acceleration and transmits full power without slippage. Clutch has only one moving part. The standard model is made with a ⅝-in. bore and has a 2½ in. x 1A pulley. Applications include air conditioners, automatic washers, dryers, sweepers, power tools and vacuum pumps. **Automatic Steel Products Inc.**, Mercury Clutch Div., 1201 Camden Ave., Canton 6, O.

—Circle ITEM 78

Nylon Nut

is self tapping for tight lock

One-piece nylon construction of this lock nut provides resistance against corrosion, abrasion, galling, and impact. Reusable, it is self



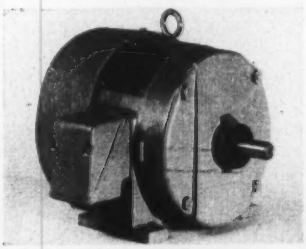
tapping to insure tight friction lock. Molded to permit installation with standard tools, nut is available in sizes from No. 4 to ¼-in. It can be provided in colors for identification or ornamentation. **American Screw Co.**, Willimantic, Conn.

—Circle ITEM 79

AC Motor

in two models for normal or corrosive service

Designated standard enclosed (normal service) and severe-duty enclosed (corrosive service), two motor lines replace former line in 1 to 5-hp range. Motors are basi-



Three Forgings That Support the Globe

In Greek mythology, Atlas was charged with the job of holding up the heavens, but right here in our own day and age is a "world" supported by forgings. It is a huge and wondrous globe that stands on the campus of Babson Institute of Business Administration, Wellesley, Mass. Its size may be judged by the people standing beneath it in the picture.

The vividly colorful globe is built to a scale of 1 inch to 24 miles. It can revolve to simulate the daily rotation of the earth on its axis. It also moves around a circular track to demonstrate the earth's orbit.

Holding the globe at its proper "tilt" is a six-ton assembly consisting of shaft, socket, and lower bearing support. All these components are forgings made and finish-machined by Bethlehem. The mounting and carriage are also products of Bethlehem shops.

Tonnagewise, the forgings in this exhibit are small. But as we've said so often, our shops welcome the lightweight jobs, and give them the same careful handling as the heavy-tonnage items. We have produced some of the biggest forgings on earth, and some of the smallest. No matter what size you may need, or what type, we will always be glad to take care of your requirements.

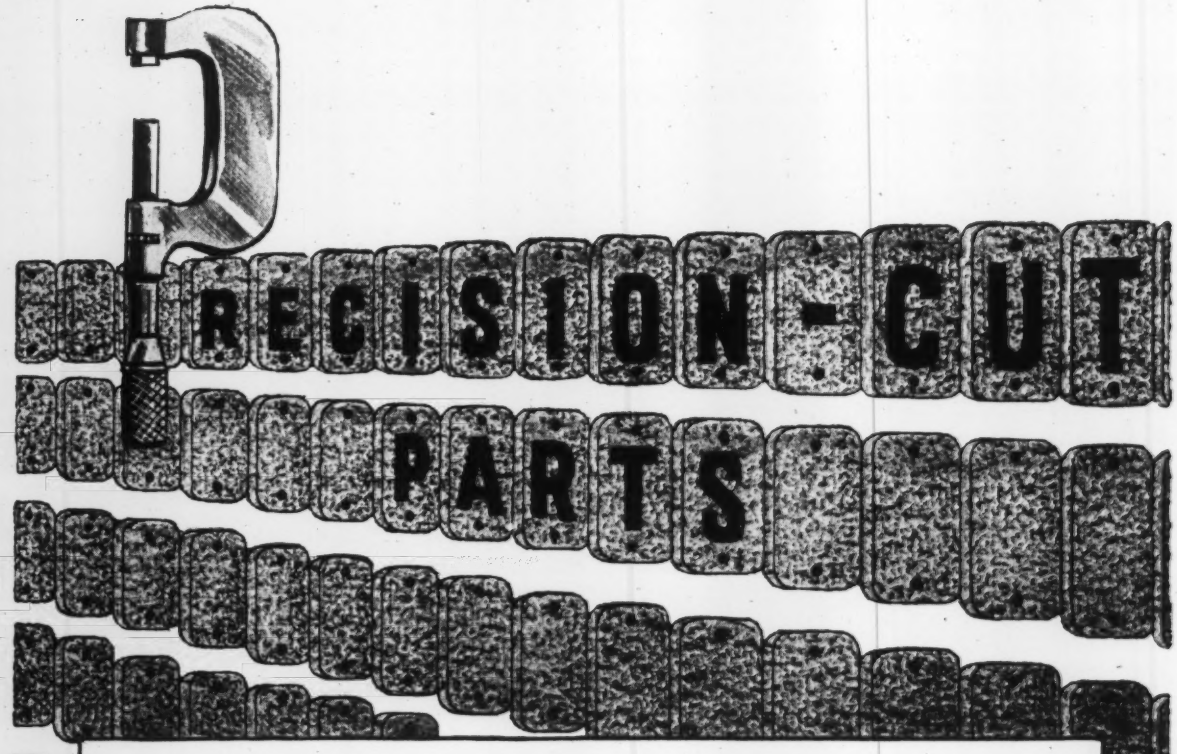
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

—ITEM 236—



our business since 1899

There is no phase in the production of wool felt in which Western Felt is not engaged. We start with lambs wool, and end with an endless variety of parts for the many jobs that only felt can perform.

Through it all, we're proud to say our methods have built an enviable reputation for engineering precision. Hard or soft, large or small, Western Felts can be relied upon to meet your specifications.

Tell us your basic problem—and we'll put 55 years experience to work in recommending a solution for you. Our engineers find new uses for felt every day. Your inquiry will receive prompt attention.

WESTERN
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Chicago 23, Illinois
Branch Offices in Principal Cities

Felt **WORKS**

MANUFACTURERS AND CUTTERS OF WOOL FELTS

—ITEM 237—
For More Information Circle Item Number on Yellow Card—page 19

cally identical, except for features which make the severe-duty model suitable for use in corrosive or excessively moist atmospheres. In standard motor, conduit box and fan cover are steel. Severe-duty motor, illustrated, has cast iron conduit box and fan cover. Neoprene washers are used on through bolts for additional moisture protection. Foot-mounted motors in both models are equipped with lifting eyes. **General Electric Co.**, Small Integral Motor Dept., Fort Wayne, Ind.

—Circle ITEM 80

Air Cylinders

in double-acting or single-acting models

Developing thrust equal to the applied air pressure, Han-d-Air cylinders are available in either double-acting style (power advance and retract) or in single-acting style (power advance and spring return). Stroke length can be specified from 1 to 4 in. in either model. Suitable for clamping, parts positioning, and light-duty work-feeding operations, the cylinders can be front or side-mounted, flange mounted, or front pivot mounted. The 5/16-in. piston rod is threaded to permit connection to load members. **Bellows Corp.**, Akron 9, Ohio.

—Circle ITEM 81

Alternator

for heavy-duty service

Line of heavy-duty alternators is designed to provide alternating current supply for passenger cars, trucks, school buses, and other vehicles which are driven slowly with frequent stops. Model 5410-G3

(*Continued on Page* 168)

—ITEM 238→

This Quick Demonstration At Your Desk Will Prove

How To Get Better, Economical Fastening With Townsend Lockbolts

A few minutes of your time invested in watching a simple demonstration of a better fastening method may point the way to savings of thousands of dollars in assembly of your products. The Townsend lockbolt provides a quick method of producing tight, rigid fastenings that cannot loosen even under extreme vibration or shock conditions.

We would like to have a Townsend engineer demonstrate to you and others in your organization how these lockbolts combine the advantages of riveting and bolting—eliminate the disadvantages. He will show you that installation is fast—that fewer workers can complete an assembly in less time—you improve your product—achieve a lower installed cost.

You will be able to see why the clamping action, or clinch, of Townsend lockbolts is higher than rivets—is more uniform than bolts and nuts. The demonstration will explain how the lockbolt fills the hole better than other fasteners—makes possible a more rigid joint and provides an effective liquid seal.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16" and 3/8" diameters, in grip length ranging up to 2", in various head styles.

For a demonstration on how to speed production, get tight, secure, permanent fastening with Townsend lockbolts write on your company letterhead to Townsend Company, P.O. Box 237-E, New Brighton, Pa.

Licensed under Huck patent nos. RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049.

THE FASTENING AUTHORITY

Townsend

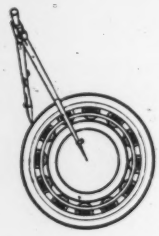
COMPANY • ESTABLISHED 1816

Sales Offices in Principal Cities

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT...

Cylindrical Rollers for High Capacity...



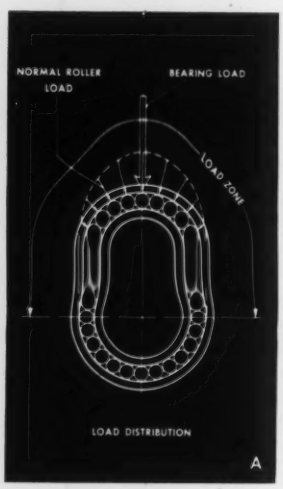
How the rollers distribute the load... effect of local deflection within rollers under load... how roller quality control increases bearing life

The principle of overcoming sliding friction with rollers was known even to the ancient Egyptian pyramid builders, but it is a far cry from their crude logs to precision-ground rollers. Today engineers have a wide choice of bearing designs, and selection is usually gaged by the fundamental yardsticks of accommodation, load-carrying capacity and cost. In many applications, properly designed plain bearings provide operating advantages. Ball bearings are ideal for other applications. But where heavy loads must be sustained in a relatively small bearing annulus, the only practical, commercially-available support is a set of hardened rollers operating in planetary fashion around a hardened inner race and housed in a hardened outer race . . . in other words, a *cylindrical roller bearing.*

Obviously, the design and quality of the *rollers* play a large part in the performance of the bearing. Here, briefly, are some of the vital factors which must be taken into consideration:

1. DISTRIBUTION OF LOAD WITHIN THE BEARING

Every roller in a rotating bearing is subjected to periods of load while in the "load zone," and periods of no load while outside the "load zone." Within this zone, the roller moves from a position of light load to a position on the line of action of the bearing load. Here the normal roller load is a maximum, and the roller in this position is the heaviest-loaded roller in the bearing. Moving beyond this point, the load diminishes to zero at the extremity of the "load zone," as shown in Diagram A at the left.

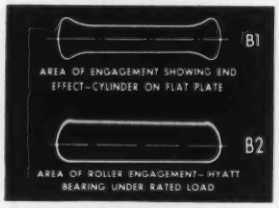


The theoretically perfect "load zone" extends from −90° to +90° measured from the line of action of the bearing load, for a total of 180°. But this is neither practical nor necessarily desirable, since it would require a bearing of zero internal clearance. If a bearing has internal clearance, then it has no "load zone" when under no load; only after load is applied does the heaviest-loaded roller deflect and permit its associates to share the load.

Under normal loadings, the actual "load zone" may range from 90° to 120°, depending on the load and mounted internal clearance. This distributes the load in the bearing so that the load on the heaviest-loaded roller can be approximated by 5/N times the bearing load, where N is the number of rollers.

2. DISTRIBUTION OF LOAD WITHIN ROLLER'S AREA OF CONTACT

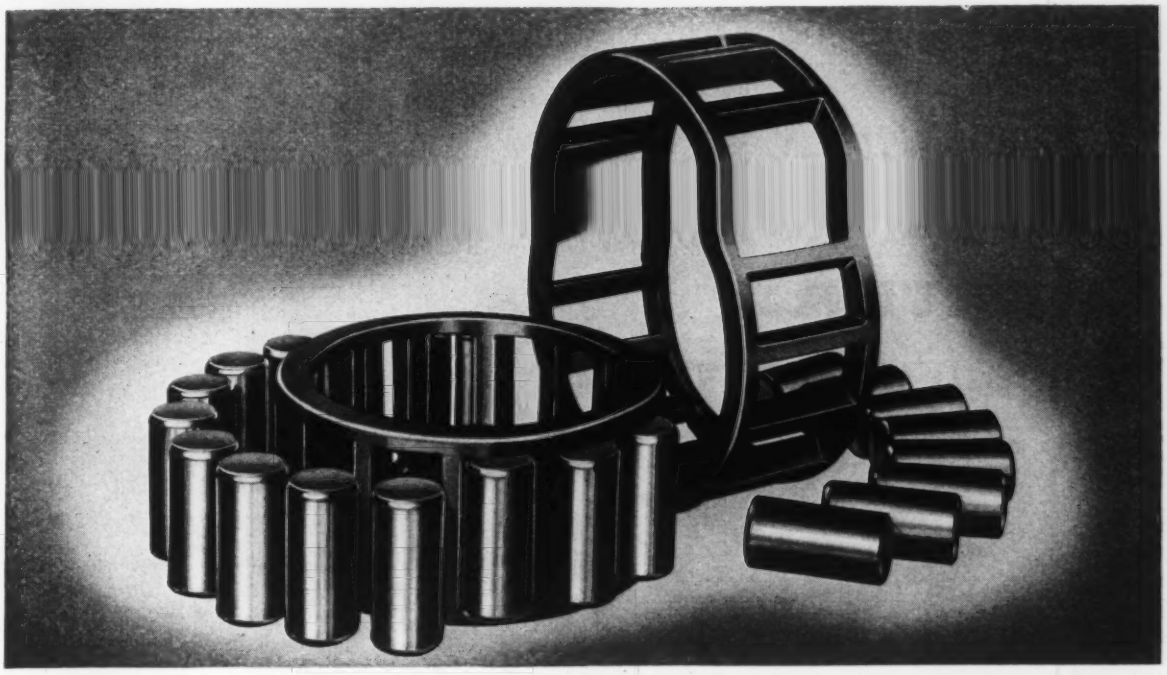
As load is applied to a cylinder between flat plates, the cylinder deflects locally in the region of engagement. The plate also deflects locally, so the original line of engagement under no load is broadened to become a "dog-boned" area (Diagram B1) under load. This broadening of the line of contact is analogous to the spread of the "load zone" from the heaviest-loaded roller to adjoining rollers, as previously described.


B1
AREA OF ENGAGEMENT SHOWING END EFFECT–CYLINDER ON FLAT PLATE
B2
AREA OF ROLLER ENGAGEMENT–HYATT BEARING UNDER RATED LOAD

One other effect is prominent here: deflected cylinders of finite length must gather in metal at their ends in *two planes*, instead of one, as is the case in the center of the roller. *This end-loading effect can seriously reduce the life of a cylindrical roller bearing.* All HYATT Roller Bearings have rollers of either generous corner radii or blended chamfers to reduce end effect. All HYATT Hy-Load Bearings, in addition to generous corner radii on the rollers, have a roller crowning extending a sufficient distance in from the ends to allow the area of contact to "fade out" evenly at the roller ends under normal loads, as illustrated in Diagram B2 above.

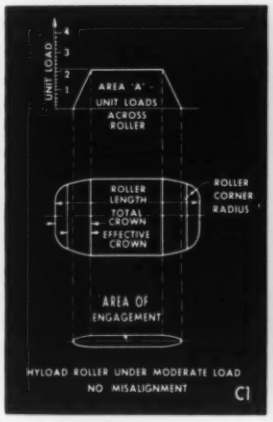
3. DISTRIBUTION OF LOAD ACROSS THE ROLLER

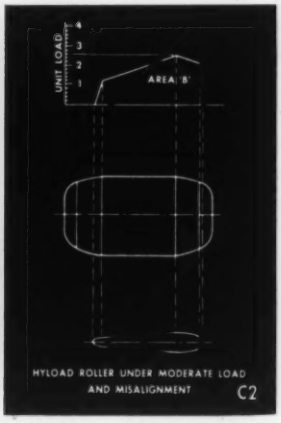
The unit load on any roller is distributed axially in a uniform manner except at the ends where crowning has been provided. Diagram C1 shows how the unit load drops off to zero at the



ends of the area of contact. The summation of unit loads represented by area "A" is the total roller load.

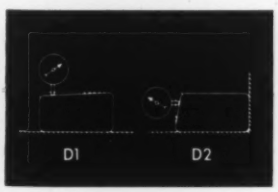
This same load applied under conditions of misalignment must result in an area "B" equal to area "A"; but it is apparent that the maximum unit load is considerably greater under such conditions and that the bearing will have a shorter life than one operating with little or no misalignment. Now observe the high unit load represented by area "C," resulting from the same total load applied to an *uncrowned* roller. This aptly demonstrates the value of crowning under conditions of misalignment. Moreover, the value of proper alignment is equally apparent (Diagram C2).



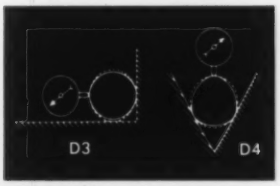


4. EFFECT OF ROLLER QUALITY ON BEARING PERFORMANCE

Quality of manufacture, particularly that of the rollers, has a great deal to do with the performance of a cylindrical roller bearing. For example:



1. A roller with excessive *taper* tends to uneven load distribution and abnormal temperature rise (D1).
2. A roller with excessive *end square* tends to noisy bearing performance (D2).
3. A roller with excessive *two-point out-of-round* tends to poor segregation and poor bearing life (D3).
4. A roller with excessive *three-point out-of-round* tends to noisy bearing operation (D4).
5. A roller with *poor finish* tends to wear on all operating surfaces and noisy operation.



6. A bearing with excessive *roller-to-roller diameter variation* tends to poor bearing life.
7. A bearing with excessive *roller-to-roller length variation* tends to poor thrust capacity and abnormal temperature rise.

All of these factors are scrupulously controlled by the most modern precision equipment to insure maximum performance and life for every HYATT Roller Bearing. HYATT has pioneered many advancements in the control of roller quality and is constantly seeking new ways to carry the complex loads of modern industry even more efficiently.

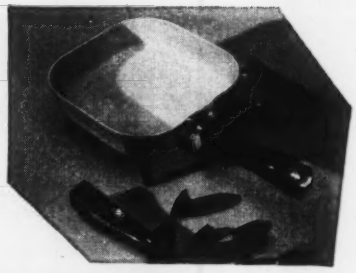
YOU WILL FIND MORE DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, N. J.

GM GENERAL MOTORS

HYATT ROLLER BEARINGS

PRODUCT DESIGN WITH DUREZ PHENOLICS



Fry Pan's
HEATER
is **CAST-IN**

what can our phenolics help YOU do better?

● Many a trail leading to manufacturing short cuts and better product service is being blazed with Durez phenolics—the basic engineering plastics. One of recent note resulted in this fry pan with its electric unit molded right into the metal casting during the shell molding operation. Casting the metal in shells bonded with Durez resins, this manufacturer reduced assembly and machining operations, saved on labor costs, and practically eliminated spoilage. Then he finished off a superior product with a beautiful jet-black, heat-resistant handle, legs, and cover knob molded of Durez phenolic plastic.

Durez phenolic resins or molding compounds, or both, could help you solve design or production problems that no other material can do so well. Talk with your molder . . . or call on our technical field men.

IF YOU ARE interested in casting by the shell mold process ask for our "Guide to Shell Molding". If you are interested in formed plastic parts, ask for "Facts on Phenolics".

DUREZ®

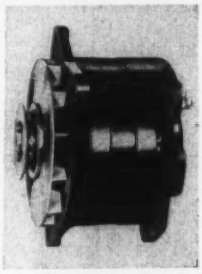
DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
Phenolic molding materials and phenolic resins that fit the job
HOOKER CHEMICALS
502 WALCK ROAD, NORTH TONAWANDA, N. Y.

—ITEM 240—
For More Information Circle Item Number on Yellow Card—page 19

New Parts

(*Continued from Page* 165)

has 6-v, 95-amp rating and is suited for vehicles with radio-telephone equipment. Model 5412-G6 is rated at 12 v, 50 amp and can be mod-



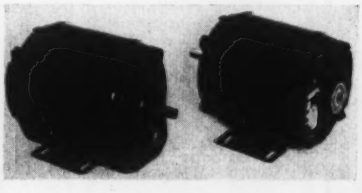
ified to provide 125 amp. An auxiliary transformer can be used with either model if 800-w, 110-v output is desired. **Leece-Neville Co.**, 1374 E. 51st St., Cleveland 3, O.

—Circle ITEM 82

Fractional-Horsepower Motors

are lightweight and compact

Design of 48-frame motors incorporates high-pressure cast aluminum end brackets which are precision machined and stress-relieved for permanent dimensional accuracy. For cooling, an integrally cast, cluster type aluminum fan is used. The square stator iron allows space for a strong blast of cooling air to pass between the frame and the core to cool the



whole core. Motors are rated 1/20 to 1/3-hp. The standard frame is completely dripproof. Totally enclosed, unit heater, permanent split capacitor and other types are available with rigid or cushion bases. **Century Electric Co.**, 1806 Pine St., St. Louis 1, Mo.

—Circle ITEM 83

Enclosed-Motor Pump

handles corrosive liquids

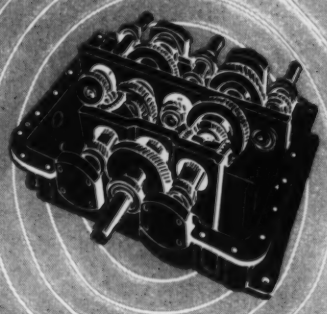
Double-ended Chempump, rated at 3 hp, is suitable for leakproof handling of liquids that are corrosive,

Facing Page—ITEM 241→

FAIRCHILD SPEED CONTROL

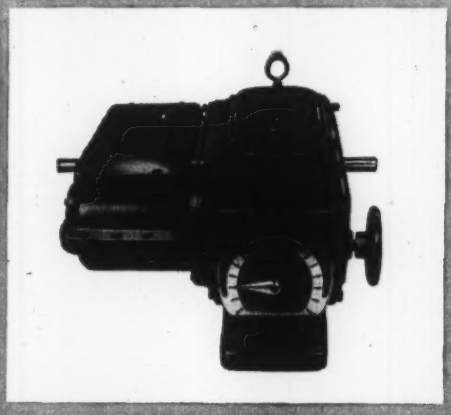
PRODUCTS SOLVE ACCURATE DRIVE CONTROL PROBLEMS

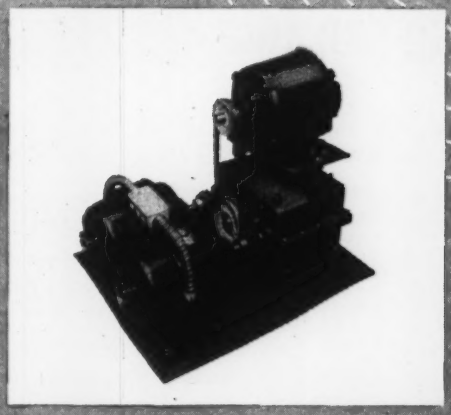
Improved production and quality control in metal, rubber, paper, synthetics, wire, glass and many other fields.



OUTSTANDING FEATURES

- Wide speed range including zero and reverse
- Maximum efficiency and power utilization
- Full torque at zero speed
- Instantaneous response to control signals
- Control simplicity
- Service-free dependability

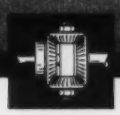




For precision of speed and tension control specify Fairchild Specon products. These compact units provide improved production without the need for costly complex controls. Specon variable speed characteristics enable you to adjust easily for variations in material, build up, shrinkage, gauge differences and moisture content. Highly adaptable, Specon perfected tension control can be tailored to your specifications.

A basic adjunct to today's automated methods, Specon has been adopted by leading American manufacturers. It is available in *Electrical Differential* and *Mechanical Differential* models. Both units, by means of a uniquely designed bevel gear differential, effect optimum speed control through wide ranges *including zero and reverse*. Where extremely close control is required within a narrow speed band, Specon Mechanical Draw transmissions will maintain accuracies of speeds and settings not previously available to industry.

Backed by the technical resources and know-how of aviation's pace-making Fairchild Engine and Airplane Corporation, the Speed Control Division offers advanced engineering in variable speed application. Speed Control will be pleased to analyze your drive problem. Write today to Dept. T.



ENGINE AND AIRPLANE CORPORATION

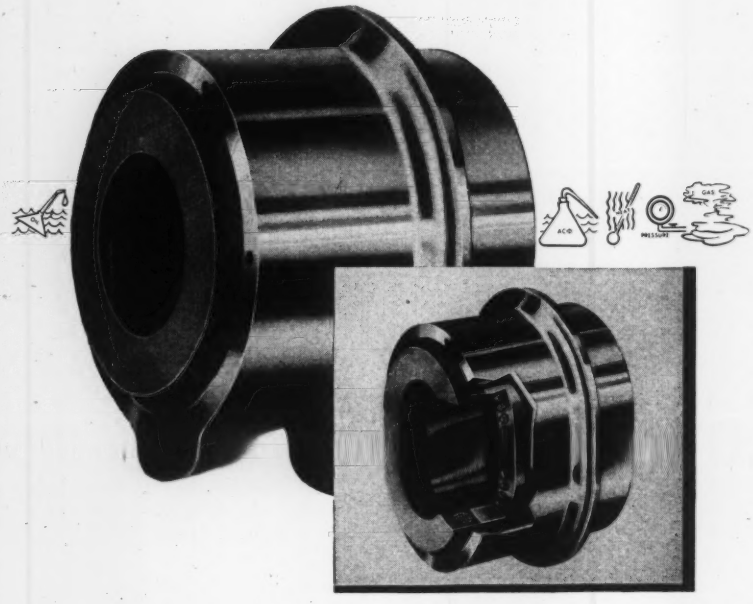
FAIRCHILD

Speed Control Division

St. Augustine, Florida

Aircraft Division, Hagerstown, Maryland • American Helicopter Division, Manhattan Beach, Calif. • Engine Division, Deer Park, L. I., N. Y. • Guided Missiles Division, Wyandanch, N. Y. • Kinetics Division, New York, N. Y. • Stratos Division, Bay Shore, N. Y.

SPECIAL



nothing can touch this winding

Oil, acid, vapor, heat and pressure don't affect this AC motor winding. It's completely encased in a special, high-temperature, chemical-resistant plastic. The windings are cast right in the plastic to make a single, solid, impervious piece.

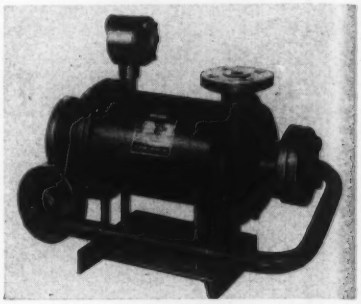
Of course, this winding goes into a special motor — one that's designed to run in a pressurized atmosphere of inert gas, under constant exposure to a piping-hot oil splash and vapor at over 200°F. Temperature-stabilized bearings, oil lubricated under pressure, and drip-proof, corrosion-resistant construction are some other design necessities for this unique 115-volt, 1/3 hp AC motor.

Here is a typical example of ESCO's unusual ability to design and build rotary electrical equipment to meet special customer needs. Whether or not your particular motor problem is this special, remember that ESCO's twenty years of broad experience is always available to you. No motor or generator problem is too big or small, too routine or specialized for ESCO engineers and craftsmen to solve properly, the way you want it solved.

Refer to Esco Catalog in section $\frac{4a}{E1}$ in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem . . . we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

New Parts



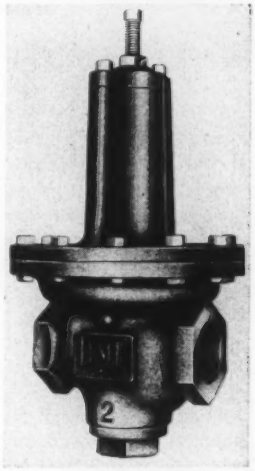
toxic, explosive or radioactive. Pumping chambers of the two-stage unit can be piped in series, as shown, or parallel for compact high-head or high-volume pumping. Overall size of the pump is approximately 2 x 1 x 1½ ft. It provides heads to 230 ft. Standard temperature limit is 450 F; pressure limit is 300 psi. Pump can be fabricated from cast iron, cast steel, 300-series stainless steel, Monel or Carpenter-20. **Chempump Corp.**, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

—Circle ITEM 84

Pressure Reducing Valve

provides constant flow

Hi-Flo regulator for noncorrosive liquids provides constant flow despite wide fluctuations in inlet pressure. Balanced for smooth throttling action, the valve employs a long-travel diaphragm and a large bowl to insure full flow. Classes W-1 and WL-1 are available in cast-iron bodies from ½ to 2 in. Inlet pressure range is 10 to 250 psi at 180 F; exit regulated pres-



SITTING PRETTY...

...on LORD foot mountings

The new Burroughs' Ten Key Adding Machine has foot mountings designed by LORD. Despite their apparent simplicity, the mountings had to (1) assure noiseless, cushioned performance, (2) match the machine's color, and (3) overcome migratory and contact staining of desk tops.

The LORD bonded-rubber mounting shown was designed to meet these tough requirements. It effectively isolates vibration by separate mounting of chassis and base. The specially compounded rubber does not stain or mark desk-top surfaces. Color-matching was achieved without impairing the good vibration control characteristics. As a result, Burroughs' new machine is "sitting pretty"—with its advantages of quiet operation, attractive appearance and non-marking feet assured by LORD mountings.

LORD can make bonded-rubber foot mountings in a variety of sizes and shapes to enhance the beauty and operational appeal of your business machines. We will be glad to discuss specific applications with you. Contact LORD today.

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

NEW YORK, N. Y. - Circle 7-3326 • PHILADELPHIA, PA. - LOcust 4-0147
CLEVELAND, OHIO - SUperior 1-3242 • DAYTON, OHIO - Michigan 8871
DETROIT, MICH. - TRinity 4-2060 • CHICAGO, ILL. - Michigan 2-6010
DALLAS, TEXAS - Riverside 3392 • LOS ANGELES, CAL. - HOllywood 4-7593
"In Canada—Railway & Power Engineering Corporation Limited"

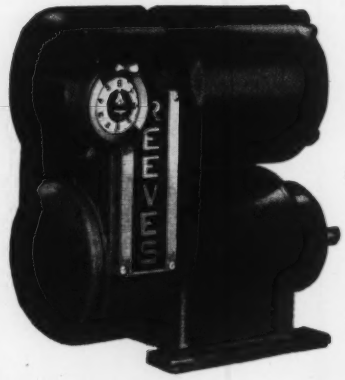
LORD MANUFACTURING COMPANY • ERIE, PA.

—ITEM 243—

REEVES

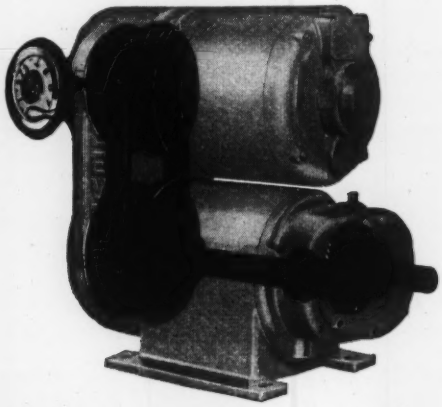
the right speed for every need!

fractional HP Vari-Speed MOTODRIVE



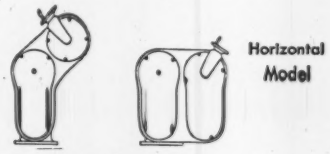
compact, attractive design

Within streamlined, metallic blue housing is REEVES' "weatherized" motor, time-tested speed changing mechanism, and heat-treated helical gear speed reducer. Maximum space for vertical model only 16 5/16" x 21½" x 11½". Other models equally compact.



simple, accurate operation

14-turn handwheel on Speedial indicator gives you stepless, accurate speeds from 3 to 4660 rpm's—within a 2:1 to 10:1 speed range. Electric remote or automatic controls also available.



versatile application

Select your *exact* needs from 112 assemblies: ¼, ½ or ¾ hp. units; horizontal left or right, vertical, or 45° left or right models; horizontal or vertical down output shaft.

Write Dept. H19c-M543 for complete bulletin.

REEVES PULLEY COMPANY • Columbus, Indiana
Division of RELIANCE Electric and Engineering Co.

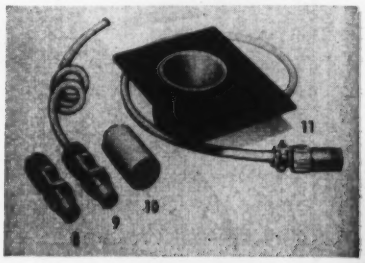
sure ranges are 5 to 30 psi or 25 to 80 psi. **Leslie Co.**, 77 Delafield Ave., Lyndhurst, N. J.

—Circle ITEM 85

Hollow-Coil Pickup

counts metal parts at rate of 12,000 per minute

Hollow-coil proximity pickup Model 4920 (No. 11) accurately counts or indicates nuts, screws, or other metallic parts as they pass through



the hollow coil. Counting rate can be as high as 12,000 per minute, and 15 sizes are available with inner coil diameters from ¼ to 3 in. Equipped with cable and connector, the pickup can be used with either of two control units. With model 4901 control, a dc signal is generated when a metal object passes through the coil. With model 4901-R control, the coil can be used to actuate electronic counters or automatic machinery. Replaceable phenolic inserts are supplied with each pickup. **Electro Products Laboratory**, 4500 N. Ravenswood Ave., Chicago 40, Ill.

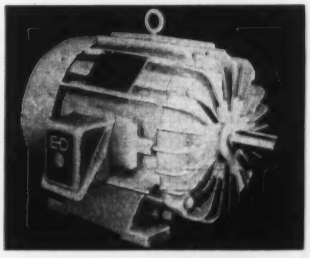
—Circle ITEM 86

Totally Enclosed Motors

conform to NEMA dimensional standards

Type H rerated totally enclosed nonventilated and totally enclosed fan-cooled motors operate where

noncombustible dust and moisture



WESTINGHOUSE SAVES $18,043 with USS "T-1" STEEL

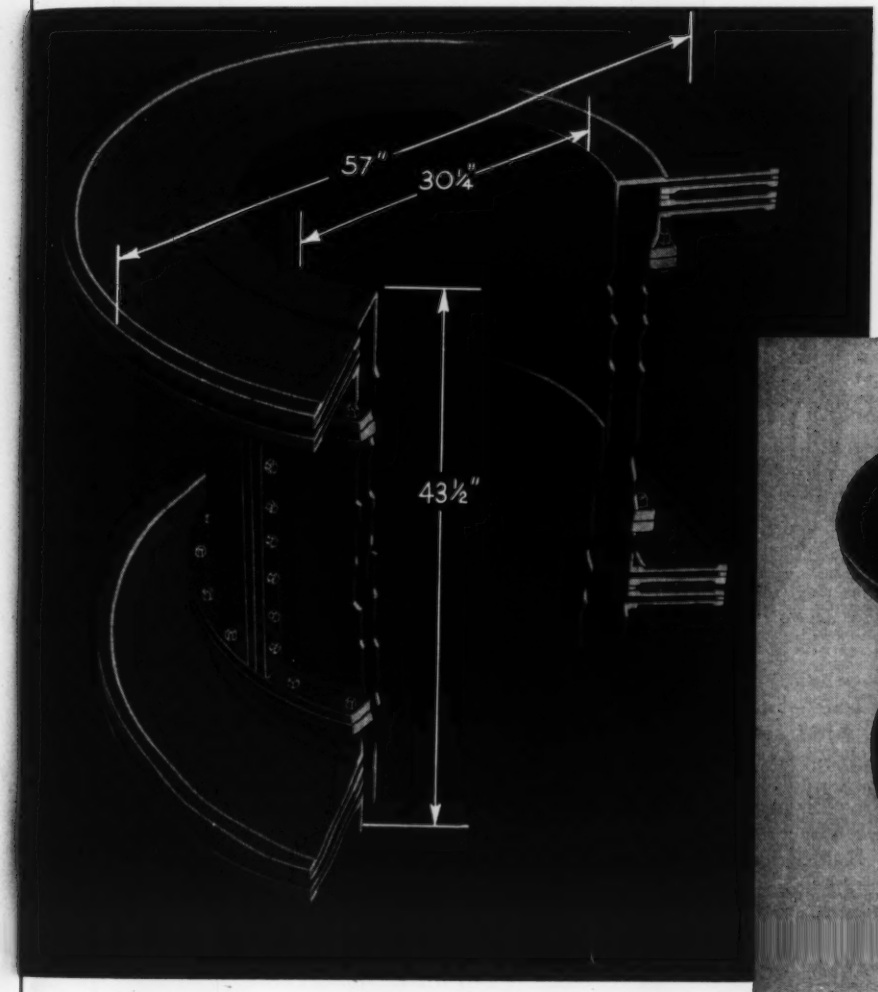
The Sunnyvale, California plant of Westinghouse Electric Corporation controls vibration of huge wind-tunnel air compressors with unusual supporting struts. Steel bellows that flex, both up-and-down and sideways, absorb and isolate the tremendous vibration in these powerful machines. Westinghouse lopped an impressive $18,043 off the cost of these bellows by switching to USS "T-1" Steel.

"T-1" costs less to machine. It costs less to weld. To top it off, "T-1" *costs less to buy* than the steel previously used. Yet it is plenty tough and strong enough to meet the rugged physical requirements.

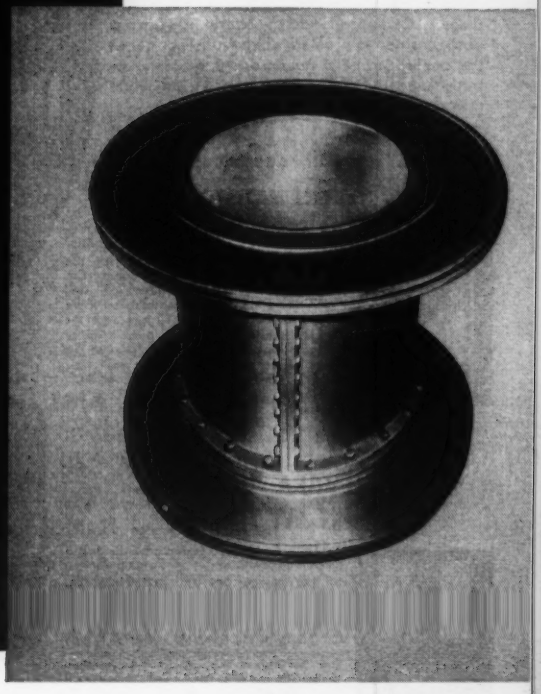
NEW WAYS TO SAVE MONEY

No other alloy steel can be used in *so many ways* to save money or improve products. Already—and "T-1" is still a relatively new steel—it has been used with great success in rotating machines, earth-moving equipment, towers, pressure vessels, mining machines, printing presses, and other heavy-duty applications.

Think of USS "T-1" when *you* need very high tensile strength (105,000 psi.) and yield strength (90,000 psi.) . . . when you need good creep rupture strength at high temperatures . . . extraordinary toughness at sub-zero temperatures . . . resistance to abrasion, impact, and abuse. All or any of these properties, plus good weldability, are yours in "T-1"! For information write to United States Steel, Room 5180, Pittsburgh 30, Pa.



STEEL BELLOWS SOAK UP VIBRATION. Here is one of the struts that support each air compressor. Two steel bellows—at the top and at the bottom of the central cylindrical section—flex and absorb the shock and stress of heavy vibration from the compressor. Tough, strong, steel was needed for the bellows. USS "T-1" does the job, and saves money for Westinghouse Electric Corporation.



UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

NOW!

control that vital operation ... automatically!

Speed up production

Cut down on waste

Save valuable time

Automation can give you the jump on competition ... and selection of the "right" industrial time controls can make a big difference in increased efficiency and reduced manufacturing costs. The AEMCO units listed below are just a few of the standard models which today occupy an important place in the nation's industry. Should you have a particular design problem which would not permit the application of a standard unit, write to our Engineering Department for information and quotations on your specialized problems.

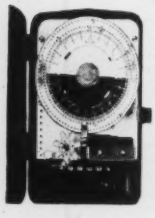
AEMCO

Manual, Automatic Re-set, or Continuous Cycling

INDUSTRIAL TIME CONTROLS

More "on" and "off" operations per cycle!

CYCLE MASTER TIME SWITCH



Not just a time switch, the "Cycle Master" may be used as a timer as well. Up to 48 separate "on" and "off" operations per cycle—available in 1, 12, or 24 hour cycling models. Time intervals between "on" and "off" operations of 37½ seconds on the 1 hour units adjustable up to 15 minutes on the 24 hour units by inserting pins. With or without skip-a-day feature in 10 and 20 amp. capacities. Also available with slide trippers; however, number of "on" and "off" operations per cycle will be reduced accordingly.

MARA AUTOMATIC RE-SET TIMERS

Actually two inter-connected adjustable timers, the MARA Series units permit varying not only the "on" and "off" periods, but also the length of the complete cycle. Units may be varied, for example to "on" 6 hours—"off" for 2 hours. This series may be supplied to operate in cycles from 10 seconds to 108 hours. Should either open or closed circuits require a short interval, one timer is provided with an extremely short time cycle for precise accuracy. Steel case measures 8"x 5"x4½"—equipped with a lockable metal hasp.

AR & MAR AUTOMATIC RE-SET TIMERS

Neat, compact, easy-to-set. MAR series available in cycles from 30 seconds up to 1 hour. The AR unit is available in cycles from 1 hour up to 96 hours. 10 amp. capacity — all models feature rapid re-cycle.

WRITE TODAY

If you have a particular design or control problem we will be happy to help you solve it with a standard or custom AEMCO timer. For complete information write to:

AEMCO

AUTOMATIC ELECTRIC MANUFACTURING CO.

65 STATE STREET • MANKATO, MINNESOTA

TIME SWITCHES • INTERVAL TIMERS • SIGN FLASHERS • RELAYS • CONTACTORS

—ITEM 246—

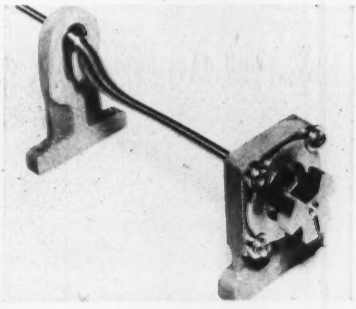
New Parts

are present. Complete housings and end brackets are solid cast iron, ribbed frame. Compact design provides higher horsepower output in less space than former models. Motors are now available on 182, 184, 213, 215, 254U and 256U frames; larger ratings will be available in the rerated frame sizes. **General Dynamics Corp.,** Electro Dynamic Div., 163 Avenue A, Bayonne, N. J.

—Circle ITEM 87

Precision Limit Stop

has adjustable limits



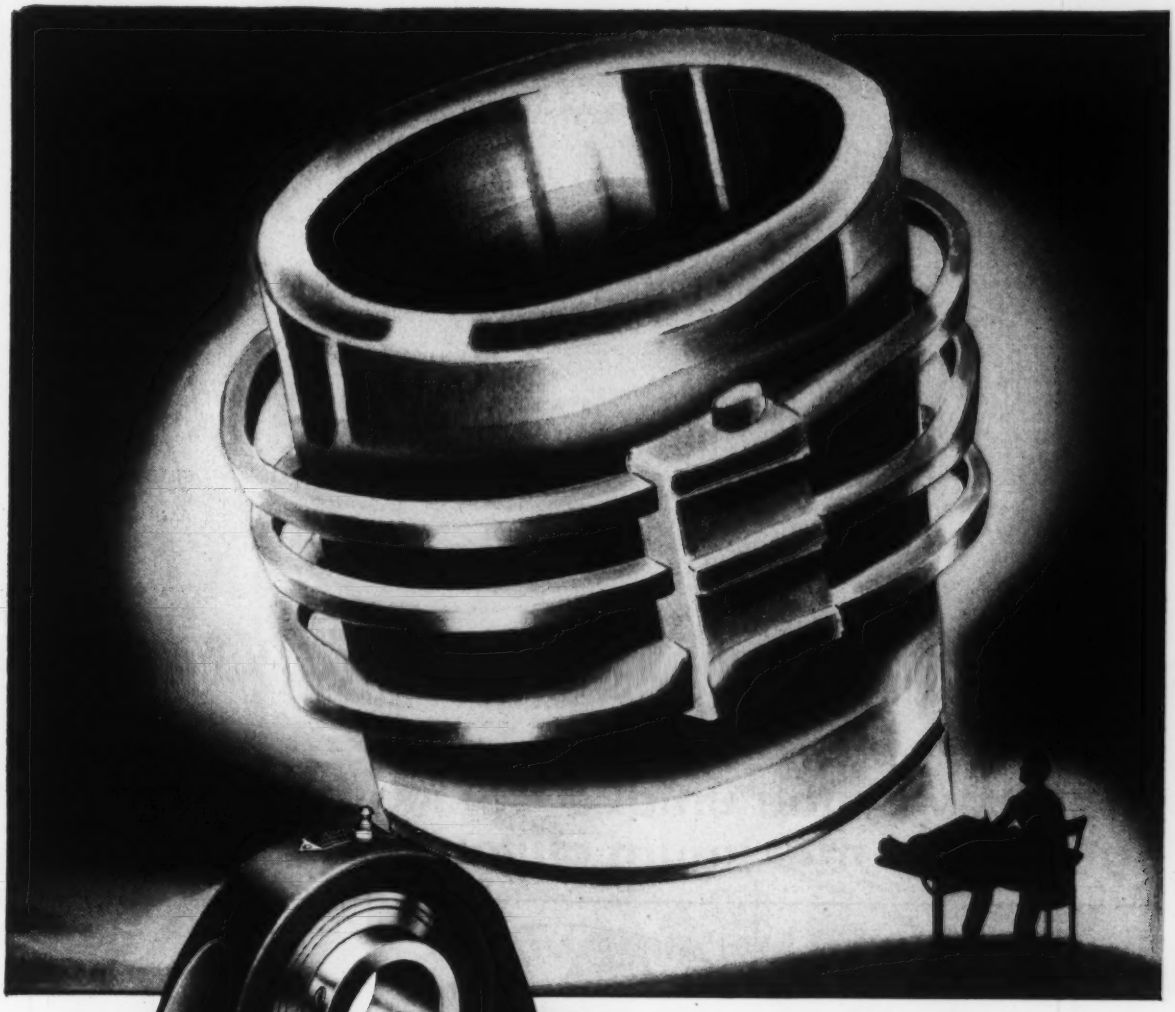
Rotational limits of this precision limit-stop assembly are adjustable from 30 to 4530 deg, depending upon the number of lug washers used and the setting of the stop ring. Rotation of the limit-stop shaft is blocked when a lug washer contacts either an adjacent washer or the frame stop. Designed to use 3/16-in. diam shafts, the assembly is stainless steel except for hangers, which are anodized aluminum. **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

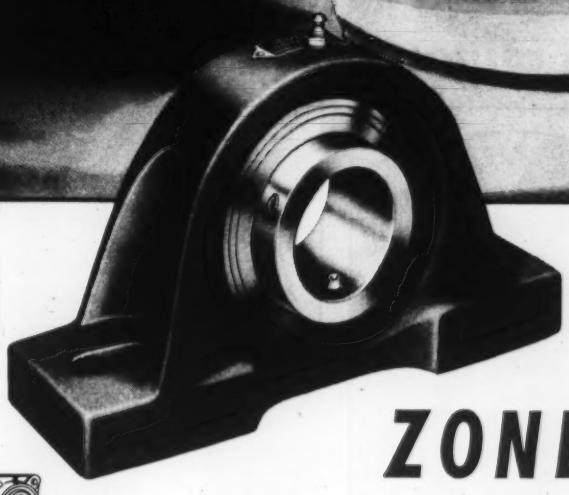
—Circle ITEM 88

Six-Circuit Control

operates from single actuation

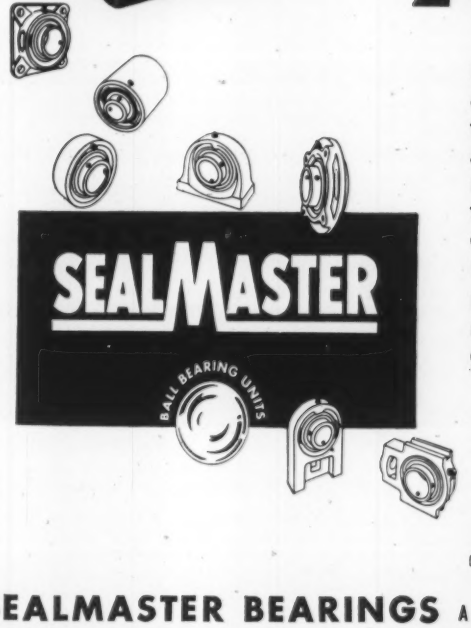
Model K3-4 triple-pole, snap-action switch controls six circuits from one actuation. It simultaneously reverses the current flow through two windings in three-phase motors up to 1 hp, as well as other types of multiple-switching installations. The instantaneous snap-action of the three poles is independent of the speed of actuation. A variety of standard actuators is available. Electrical rating is 15 amp at 125/250 v ac and at 30 v dc resistive. Material used in control housing makes





THIS ONE FEATURE *ALONE* MAKES SEALMASTER OUTSTANDING

ZONE HARDENING

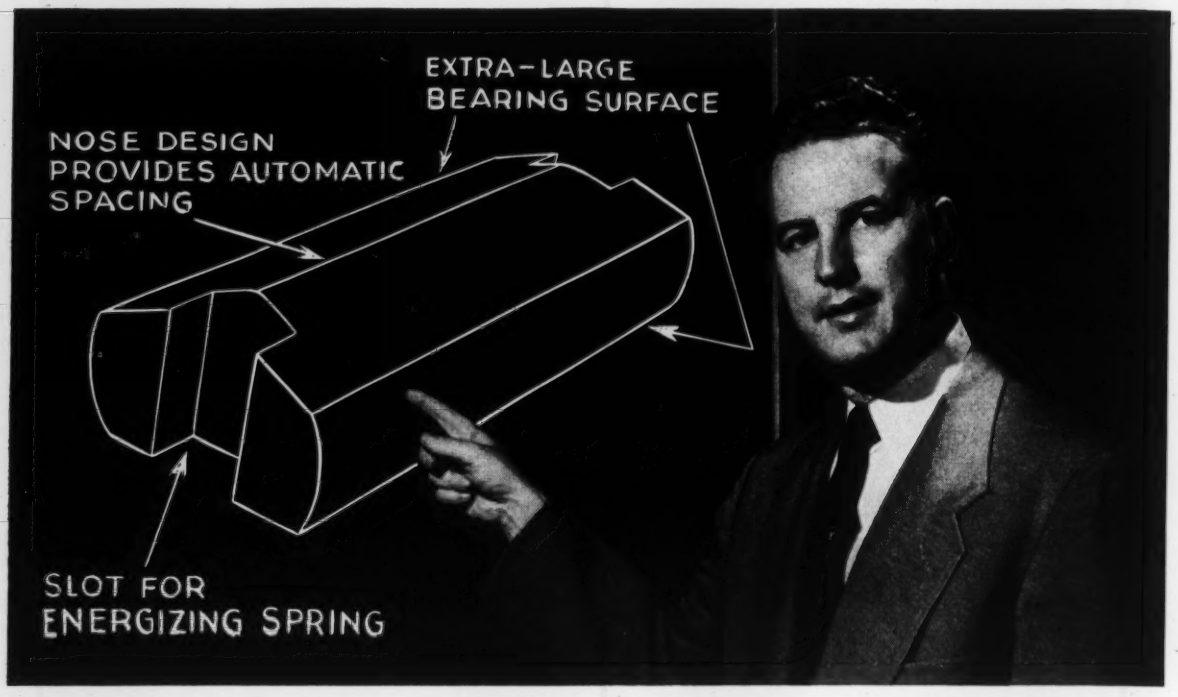


SEALMASTER Ball Bearing Units provide a patented exclusive feature, **Zone Hardening,** which assures a positive race to shaft lock. **Zone Hardening** is a completely automatic heat treating process by which the inner race ring of SEALMASTER Ball Bearing Units is hardened through the ball path and adjacent section only. The extended portion of the inner race is left in its original metallurgically soft, tough state. Hardened set-screws are mounted through this soft portion of the race, permitting race-to-shaft locking with increased holding power and greater resistance to vibration and shock.

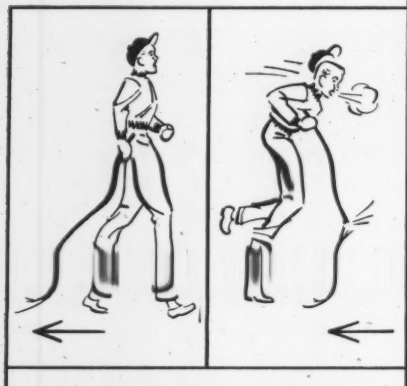
You'll want full information on the advantages of this and other SEALMASTER features—such as Self-Alignment, Locking Pin & Perimeter Dimple, Labyrinth Seal, Floating Ball Retainer, etc. Write for Bulletin 454 today.

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVE., AURORA, ILLINOIS

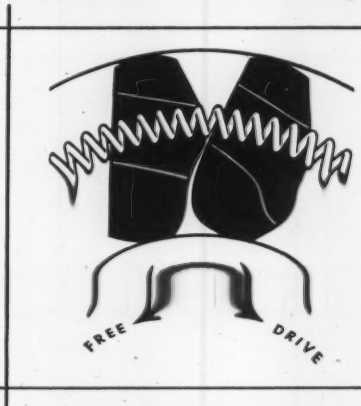
—ITEM 247—



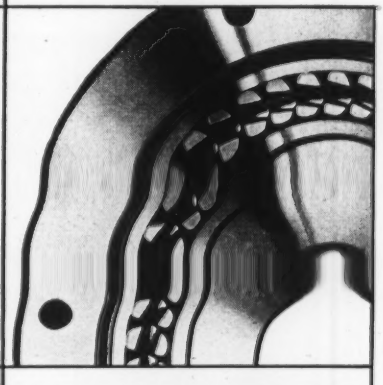
Here's why the unique design of this sprag gives you maximum clutch precision



A simple illustration of how a sprag works: A boy dragging a stick behind him finds no resistance to his efforts. However, when he pushes the stick ahead of him at a high angle—it sticks and knocks the wind out of him. The boy's body represents an outer race — the ground; an inner race. The stick represents a sprag wedged between the two races.



Sprags used in Formsprag Clutches are highly developed, precision wedges of hardened alloy steel. Due to the sprag's design, an unusually high amount of torque is delivered from one concentric race to the other. When torque is applied, the sprags are instantaneously engaged. When torque is removed, the sprags release instantaneously.



Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.

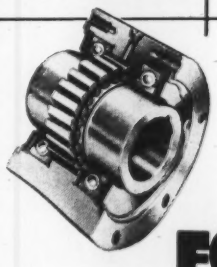
Whatever your clutch application—over-running, backstopping, or indexing—Formsprag Clutches offer you these distinct advantages:

- Higher Torque Capacity
- Longer Life
- Internal Simplicity
- No Measurable Backlash
- Exceptionally Low Maintenance

The experienced Formsprag Engineering Staff is available to recommend a standard clutch or to design one for your specific application.

Why not write for details today.

A6-1B



OVER-RUNNING—
BACKSTOPPING—
INDEXING

FORMSPRAG *Clutches*

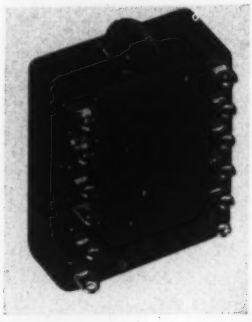
Distributors in Principal Cities

23603 Hoover Road, Van Dyke, Michigan.

World's Largest Exclusive Manufacturers of Over-running Clutches

—ITEM 248—

For More Information Circle Item Number on Yellow Card—page 19



it suitable for use at high temperatures. **Electro-Snap Switch & Mfg. Co.**, 4218 W. Lake St., Chicago 23, Ill.

—Circle ITEM 89

Needle Valve

controls corrosive fluids at pressures to 10,000 psi

Safe, accurate control of corrosive fluids is provided by this stainless steel needle valve at line pressures up to 10,000 psi. Valve body, stem, and stem guide are 416 stainless, and stem is hardened and machined with fine-pitch threads for close flow regulation. Extra-deep packing is clean, durable, and eas-

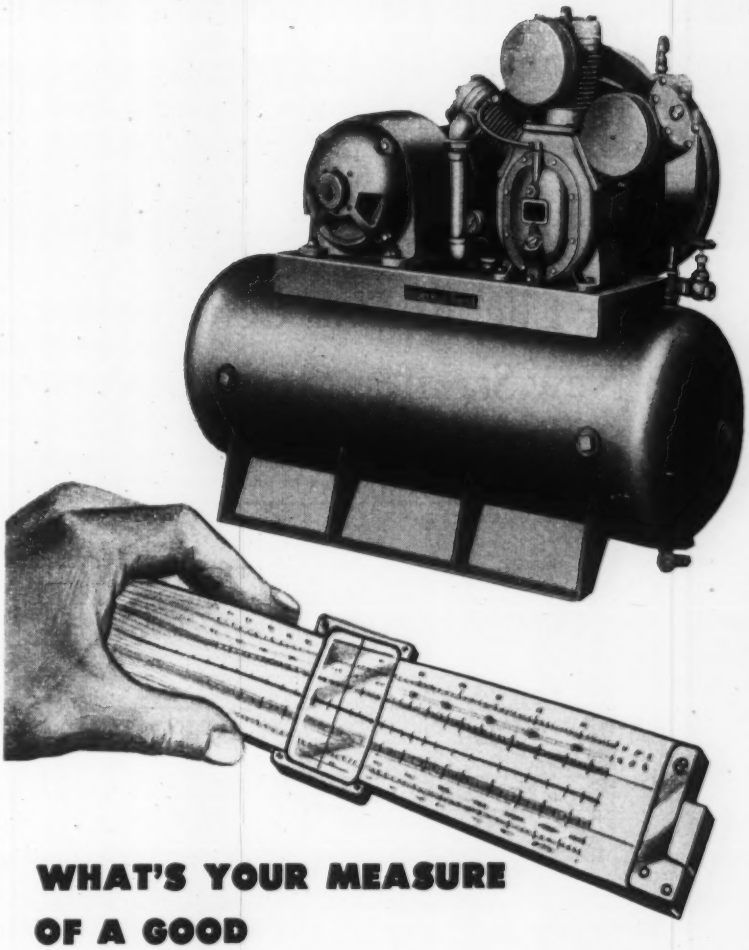
ily replaced. Pipe threads are long-length, permitting tight sealing of pipes that may be threaded undersize. **Jas. D. Marsh Corp.**, 3501 W. Howard St., Skokie, Ill.

—Circle ITEM 90

Miniature Indicator

presents alarm or position indication

Hermetically sealed Mindicator has high readability and excellent vibration resistance. Clear indi-



WHAT'S YOUR MEASURE OF A GOOD

Air Compressor?

Size for size—feature for feature—you'll do well to compare the many advantages the Ingersoll-Rand Air Compressor offers your product:

- Produces more air-per-horsepower because of design features not found in other compressors.
- Operates quietly and efficiently.
- Outlives other compressors—years longer than most as the record shows.
- Looks like Quality—and it is—compact, well constructed, durably built.

Get more detailed information on I-R Air Compressors—½ to 20 hp—and see how they can help the sale of your own equipment. For prompt response, write to:

Ingersoll-Rand

11 Broadway, New York 4, N. Y.

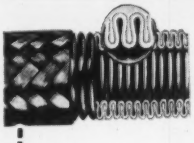
—ITEM 249—

FLEXON®
METAL HOSE
Design Briefs

Now, Greater Dependability, Longer Life for Flex Connections with New Stainless Steel Rex-Weld

Make your Selection Here...

I.D. (In.)	Nominal O.D. (In.)		Minimum Inside Bend Diameter (In.)		Burst Pressure	Weight Per Foot (lbs.)	
	RW 80	RW 81	Repeated Flexing	Static Bend	(psi)	RW 80	RW 81
¼	½	⅝	12	7¾	16,500	.20	.36
⅜	11/16	13/16	14	10¼	14,000	.27	.41
½	27/32	31/32	16	11	12,400	.47	.65
¾	1 17/64	1 13/32	21	17	10,500	.90	1.33
1	1 35/64	1 11/16	26	18	8,500	1.04	1.59
1 ¼	1 57/64	2 1/16	30	21	7,600	1.81	2.39
1 ½	2 ¼	2 7/16	35	22	6,600	2.19	2.71
2	2 37/64	3 5/64	44	24	4,650	2.97	3.78



RW-80 is unbraided, RW-81 has stainless steel braid. A complete selection of factory-attached fittings is available to meet all requirements. Data on larger sizes (to 6" I.D.) available on request.

FLEXON®
The Complete Line for good connections

REX-WELD
corrugated metal hose is available in stainless steel, steel, bronze and alloys; sizes 3/16" through 24", I.D.; for burst pressures to 18000 psi.

REX-FLEX
corrugated stainless steel hose; sizes 3/16" through 6"; working pressures to 3100 psi.

REX-TUBE
interlocked and square locked type hose and tubing in steel, bronze, stainless steel and other alloys; sizes 3/16" through 12", I.D. for low and moderate pressures and for use as conduit, ducting, exhaust, protective armor, etc.

CATALOG No. 152
gives basic specifications and application data for Flexon Metal Hose. Write for your copy, today.

New stainless steel Rex-Weld corrugated metal hose makes possible opportunities for greater economy in scores of flexible connection applications.

If corrosion is a problem, internally or externally, specify stainless steel Rex-Weld. If your cost of replacing flexible connections is high, you can reduce the frequency of replacement by specifying stainless steel Rex-Weld. Similarly, if the cost of downtime or the cost of interrupting continuous processes makes less frequent replacement of flexible connections imperative, specify stainless steel Rex-Weld.

Basic specifications for stainless steel Rex-Weld are given above. Check your requirements against this data, today, and determine where the corrosion resistance and extra durability of stainless steel Rex-Weld will pay dividends for you. Write for full information.

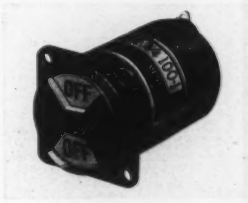
RW27

FLEXON® QUALITY
proved in service and backed by over 54 years manufacturing experience

Flexonics Corporation
CHICAGO METAL HOSE DIVISION
1339 S. THIRD AVENUE, MAYWOOD, ILLINOIS
FORMERLY CHICAGO METAL HOSE CORPORATION
Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

—ITEM 250—

New Parts



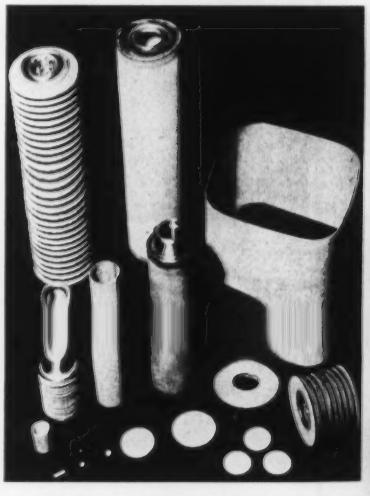
cation of alarm, malfunction, position or other information is provided by a rotating disk dial that displays colored flags in quadrant type, 90 deg openings. Face diameter is ¾-in.; body measures 13/16-in. OD by 1 17/64 in. front to back. Indicator meets requirements of MIL-E-5272A and is available in sensitivities common to moving coil dc instruments. Pointer-type display can also be provided. **Marion Electrical Instrument Co.**, Grenier Field, Manchester, N. H.

—Circle ITEM 91

Stainless-Steel Filters

for use in viscous or corrosive media

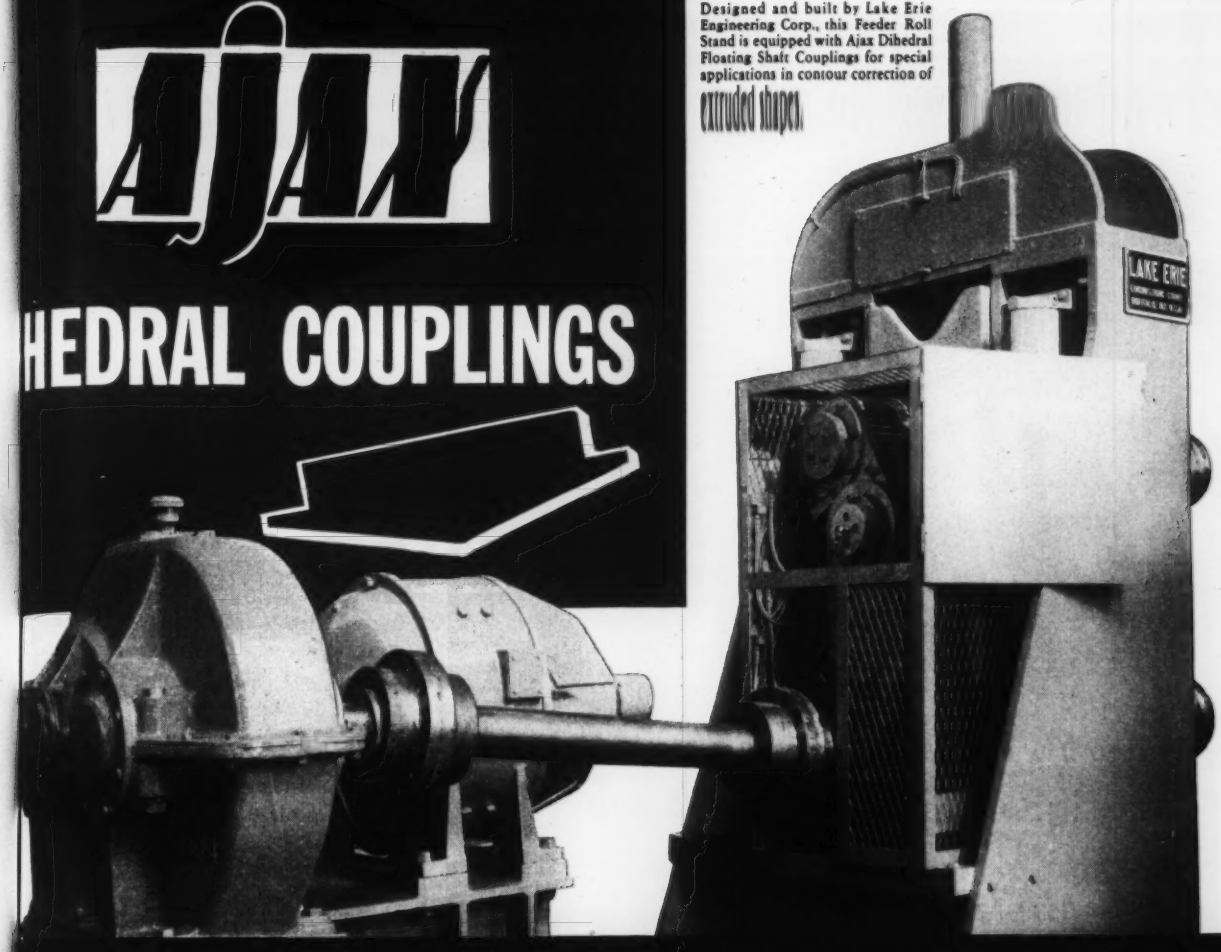
Stainless-steel Poro-Kleen filters can be used to filter corrosive liquids or gases at temperatures to 1200 F and differential pressures to 2000 psi. Filter elements, some of which are shown here, are produced from mixtures of spherical and nonspherical powdered stainless-steel alloys. After selection



according to physical properties desired, the powder is furnace sintered. Filters are built to standard AN specifications. Special designs can be provided for filtration of submicronic iron particles. These magnetic units will also remove

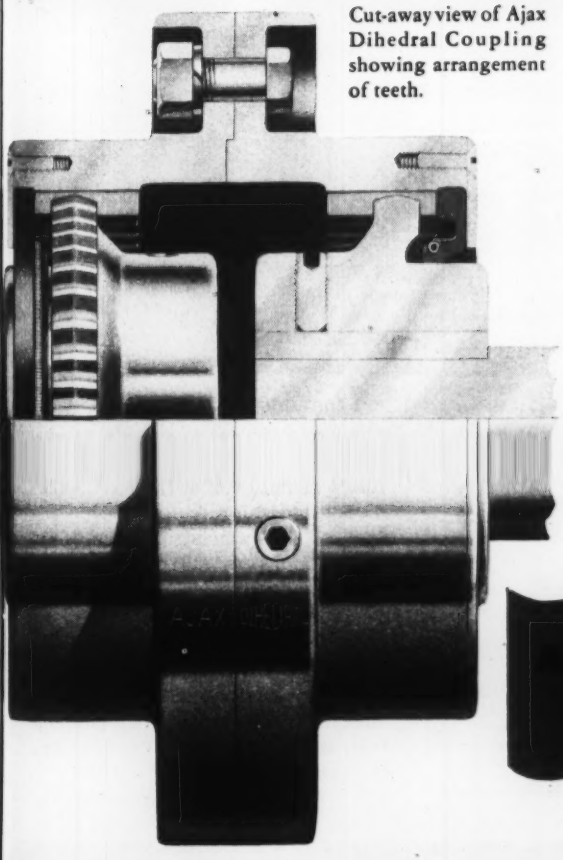
AJAX

HEDRAL COUPLINGS



Designed and built by Lake Erie Engineering Corp., this Feeder Roll Stand is equipped with Ajax Dihedral Floating Shaft Couplings for special applications in contour correction of extruded shapes.

Ending Alignment Problems of Direct-Connected Machinery

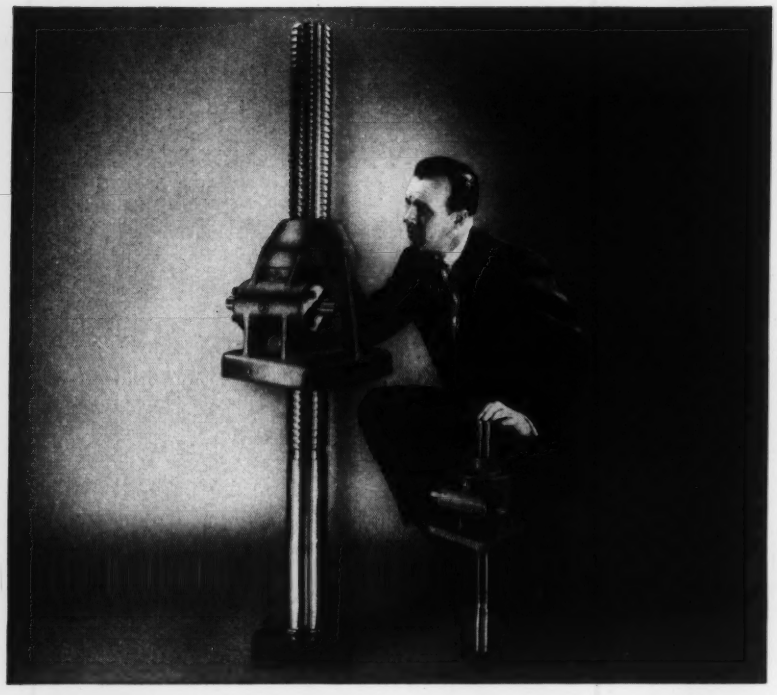


Cut-away view of Ajax Dihedral Coupling showing arrangement of teeth.

● Ajax Dihedral Self-aligning Couplings handle misalignment heretofore impossible with conventional couplings. Their ability to handle angular, offset and end float misalignment up to a total of 12 degrees is based on Ajax patented dihedral tooth design.

Get the facts on how manufacturers of presses, machine tools, rolling mills, cranes, earth moving and many other direct-connected machines are simplifying design, cutting manufacturing costs and improving performance with Ajax Dihedral Couplings. Write for Bulletin 52.

Also Manufacturers of Ajax Rubber-Bronze Bushed Couplings, and Ajax Vibrating Screens and Conveyors.



Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes or any power-operated positive control system so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 35 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. Screw ends and tops are available in many types and can be readily adapted to your specific requirements.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes or to your special order. For complete specifications and detailed drawings, send for your free copy of a special brochure.

DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

—ITEM 252—

New Parts

non-magnetic contamination of 2, 5, and 10 micron size. **Cuno Engineering Corp.**, 100 S. Vine St., Meriden, Conn.

—Circle ITEM 92

Reinforced Epoxy Tubing

resists oils, chemicals, and gases

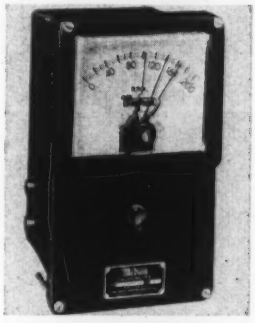
Easily machined and lightweight, glass-fiber tubing is epoxy impregnated and is resistant to most gases, fuels, oils and chemicals, at temperatures to 350 F. Moisture absorption after 90-day immersion in water is less than 1 per cent. Electrical resistivity of impregnating material is 10^{16} ohm-cm at 77F and 10^{12} ohm-cm after 35 days at 95 per cent relative humidity and 140F. Tubing is manufactured in standard lengths up to 9 ft, minimum wall thickness is 0.008-in., and diameters down to 1/16-in. ID are available. **Lamtex Industries Inc.**, 51 State St., Westbury, N. Y.

—Circle ITEM 93

Tachometer

signals high or low speeds

High and low speed limit pointers are independently set in series 42X indicating tachometer. Limit pointers act as switch contacts actuating



self-contained power relays, providing remote alarm signals or corrections for high or low-speed conditions. Unit can also be used for such actions as starting or stopping equipment and opening or closing valves. Tachometer is manually reset after relay operation. Scales are available in units such as revolutions per minute, feet per minute, or sheets per hour. **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo.

—Circle ITEM 94

ENGINEERING DEPARTMENT

EQUIPMENT

Angle Measuring Instrument

reads electrical and mechanical angles

Mechanical and electrical angles of potentiometers, switches, resolvers and similar components can be read

to ±0.1-deg by Anglyzer instrument. Angles are indicated on a 360-deg scale on the perimeter of a disk that can be rotated with the component in position. Component shaft lengths from 1/16 to 2⅛ in. are accommodated, and collets are available for shaft diameters of ⅛ and ¼-in. **Waters Mfg. Inc., P. O. Box 368, South Sudbury, Mass.**

—Circle ITEM 95

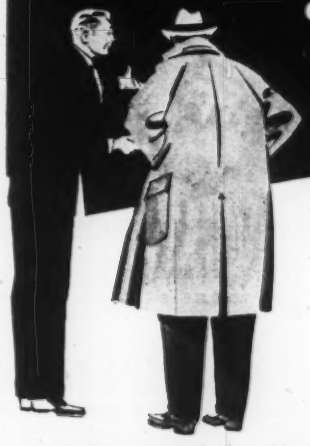
Strain Gage Kit

for experimental use

Offered for experimental use without gage guarantees, SR-4 strain-gage kit contains ten gages, four types of cement, application tools and instructions. Temperature limits of the four cements are 700, 900, 1100, and 1800 F. Gages consist of etched-foil grids 0.0005-in. thick mounted on temporary carriers. On application, carriers are stripped off, leaving the grids embedded in a ceramic cement. Nichrome, Nichrome V, and Constantan grids are available in lengths of ⅜, ½ and 1 in. Manufacturer's tests show that the gages can be used in static tests up to 1100 F. At higher temperatures, gages can be used only for dynamic tests. Nominal gage resistance is between 97 and 120 ohms, and gages in a

look to ESCO for ALLOY AVAILABILITY

HASTELLOY B & C ALLOY 20
INCONEL MONEL
PRECIPITATION HARDENING GRADES
0.03 MAX. CARBON



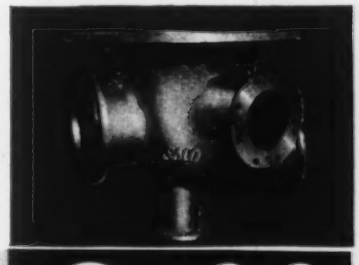
YOU GET FAST DELIVERY... even on small orders of special alloys...

Hastelloy B & C, Monel, Inconel, Alloy 20, 0.03 Max. Carbon, Precipitation Hardening Grades are just a few examples of alloys that are available—fast—when you need them. No waiting for long runs of standard production items to be completed before your order can be started. Big orders can be handled efficiently and economically too. A complete metallurgical laboratory enables *ESCO* to take advantage of the latest technological advances. Result: Outstanding quality control on every order.

UNUSUAL SHAPES AND SIZES ARE NO PROBLEM EITHER...

ESCO can supply you with static or centrifugal castings in wall sections and dimensions to meet your most exacting requirement. *ESCO* Shellcast is available, too, where needed.

Ask for details or write for free booklets... "How to cut Costs With *ESCO* Spuncast ®"... and "*ESCO* Stainless and High Alloy Products for the Process Industries".



specialists in high alloy steels

ESCO HIGH ALLOY DIVISION

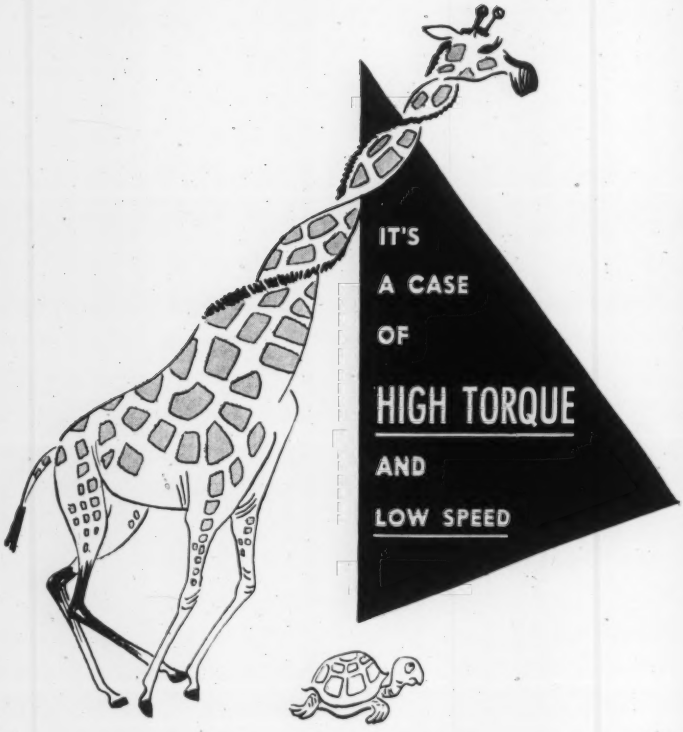
ELECTRIC STEEL FOUNDRY CO.

Manufacturing Plants
2183 N.W. 25th Ave. Portland 10, Oregon
712 Porter St. Danville, Illinois

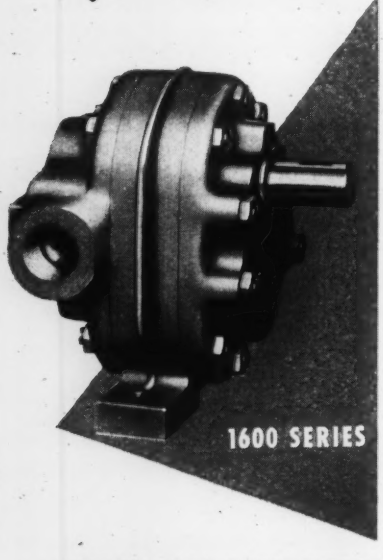
ESCO International and New York Office
420 Lexington Ave., New York City, N.Y.

Other Offices and Warehouses
Los Angeles, San Francisco, Calif. Seattle, Spokane, Wash. Houston, Texas Eugene, Ore. Salt Lake City, Utah Honolulu, Hawaii In Canada, Vancouver, British Columbia and Toronto, Ontario.

—ITEM 253—



The new ROPER
HYDRAULIC PUMP-MOTOR
for Improved INDUSTRIAL SERVICE



Designed by the same engineers who developed the famous Roper Rotary Pumps, the new Roper Hydraulic Pump-Motors operate on the same principle using two equal size, smooth-running gears in a precision-fitted case. These units offer low-speed and high-torque (much needed in the hydraulic field), and their versatility finds them well-suited to heavy-duty service within their operating range. They run equally well in either direction both as pumps or motors . . . they can be direct-connected without speed reducers, thus conserving space . . . they are easily installed, easy to operate, and are long on economy. Perhaps *you* have equipment that can be further improved with a Roper Hydraulic Pump-Motor. Send for all the facts today.

PERFORMANCE CHARACTERTISTICS

Available in foot and flange mounted models. Recommended speed range on larger sizes is from 200 to 800 RPM with pressures to 800 PSI In this range, Roper units require from 7 to 40 GPM flow and will develop up to 11.5 HP output at maximum speed and pressure. Smaller sizes may be operated up to 1200 RPM and up to 800 PSI which will require a flow of 16 GPM to develop up to 5 HP.

SEND FOR BULLETIN 22

ROPER
Rotary Pumps

GEO. D. ROPER CORPORATION • 242 Blackhawk Park Ave., Rockford, Ill.

—ITEM 254—

Engineering Equipment

kit are matched to ±0.2-ohm. **Baldwin - Lima - Hamilton Corp.**, Philadelphia 42, Pa.

—Circle ITEM 96

Drafting Accessory

protects drawings against smudging and tearing

Attached to the front edge of any drawing board, the Spiroll drafting board accessory receives the bottom edge of a drawing. Slight pressure on the sheet coils it inside the metal cylinder. Paper is adjustable to bring any section of a drawing into a comfortable position on the board. The device keeps drawings free from smudges, wrinkling, and torn edges and does not interfere with the use of drafting instruments. Hinge mounted, the Spiroll is made in 42, 48, 54, and 60-in. lengths. **Spiroll Products Co.**, 1 Concord Rd., South Sudbury, Mass.

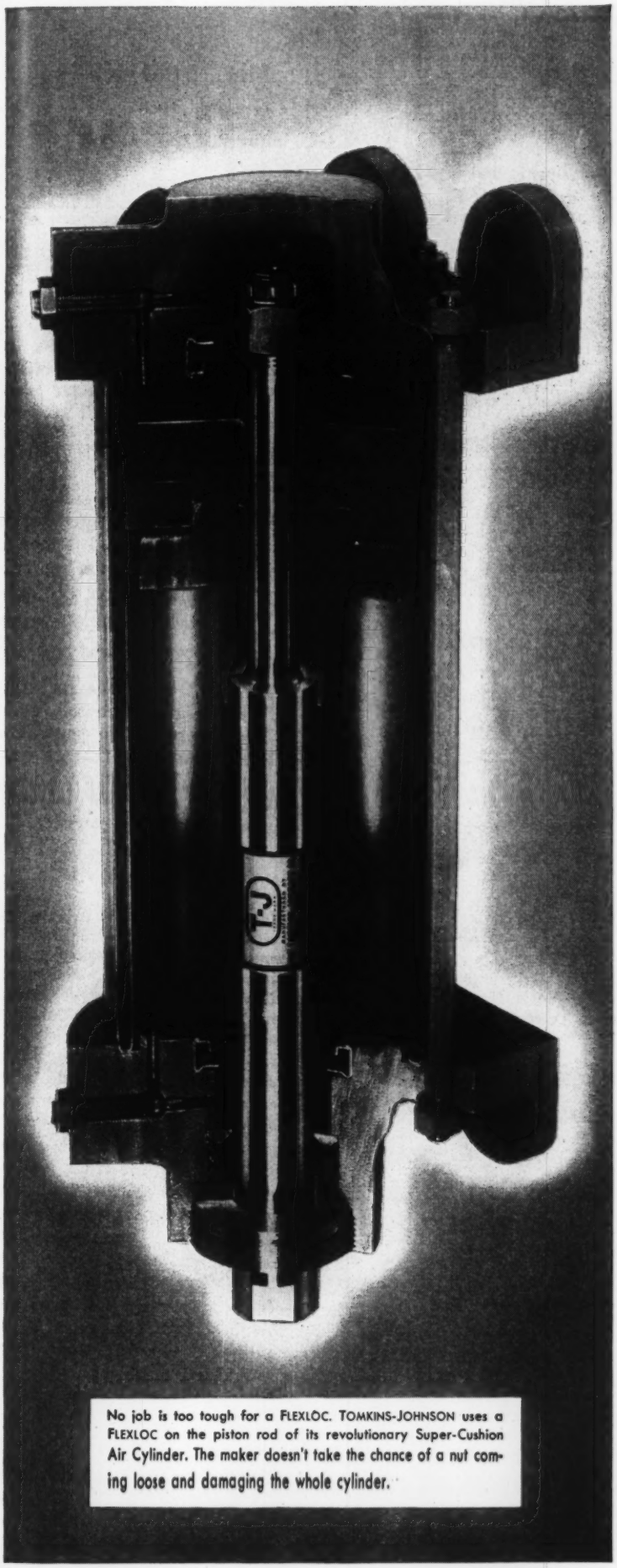
—Circle ITEM 97

Perspective Drawing Grids

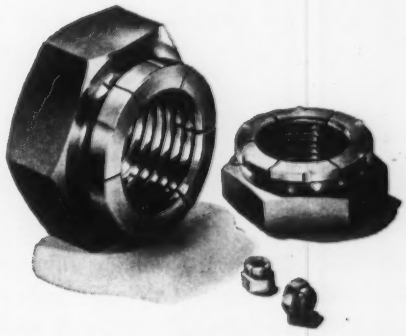
for speed and accuracy

Twenty-one grids in three different sizes comprise the basic Precision Perspective grid set, which provides accuracy and speed in perspective drawing. The seven grids in any size are progressively displaced from each other in 20-deg steps. Rotation of the basic set allows an object to be represented in 81 different positions. A selector chart is included for determining the grid size and angle to be used for the view desired. Grid sizes are 11 by 11 in., 22 by 22 in., and 40 by 40 in., for perspective drawings intended to be viewed at normal, twice normal, and four times normal reading distance. **Perspective Inc.**, 402 American Bldg., Seattle 4, Wash.

—Circle ITEM 98



No job is too tough for a FLEXLOC. TOMKINS-JOHNSON uses a FLEXLOC on the piston rod of its revolutionary Super-Cushion Air Cylinder. The maker doesn't take the chance of a nut coming loose and damaging the whole cylinder.



What FLEXLOC locknuts do for you

FLEXLOCS eliminate complicated, time-consuming methods of locking threaded fasteners. They offer simpler, faster application and safer, more dependable locking than plain nuts and lockwashers, castellated nuts and cotter pins, or nuts and jam nuts. And they won't work loose.

The reasons for all this are plain. FLEXLOCS are one piece—nothing to assemble, come apart, lose or forget. FLEXLOCS are all metal—have higher tensile than most other locknuts and are not affected by temperatures to 550°F. FLEXLOCS are both stop and locknuts—don't have to seat to lock, and stay put anywhere on a threaded member as soon as their locking threads are fully engaged.

SPS can deliver any quantity of FLEXLOCS in a wide range of sizes. Stocks are carried by industrial distributors everywhere. Write for literature. SPS, Jenkintown 18, Pa.

FLEXLOC®

LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

—ITEM 255—

design data

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Listed below are 18 different reprints of major articles which have appeared in MACHINE DESIGN . . . each a valuable supplement to your "working" library. To get your copies, simply indicate the desired number in the box opposite each title, fill in your name and address below, and send this form to MACHINE DESIGN Reader Service, Penton Building, Cleveland 13, Ohio. (Remittance enclosed will insure faster handling of your order.)

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THE ENGINEER'S Library

Recent Books

Arithmetic Operations In Digital Computers. *By R. K. Richards, development engineer, International Business Machines Corp.; 397 pages, 6 by 9 inches, clothbound; published by D. Van Nostrand Co. Inc., New York; available from* MACHINE DESIGN, $7.50 *postpaid.*

This text has been prepared to explain how a digital computer works. The first chapter concerns symbolic representation of quantities. Chapters following cover arithmetic operations and programming. Binary and decimal systems are treated separately. Principles of operation are emphasized but some explanations are patterned after particular machines that are typical of a category.

♦

Industrial Lubrication Practice. *By Paul D. Hobson, research associate, Pennsylvania State University; 548 pages, 6 by 9 inches, clothbound; published by the Industrial Press, New York; available from* MACHINE DESIGN, $8.00 *postpaid.*

Intended to provide basic information for machine designers and specialists in related fields, this book emphasizes practice rather than theory. The first section summarizes principles and techniques. Chapters cover plain and antifriction bearings, and storage, handling, purification and reclamation of lubricants. Fourteen chapters cover lubrication of particular machines and components. The last chapter concerns storage preservation of machinery.

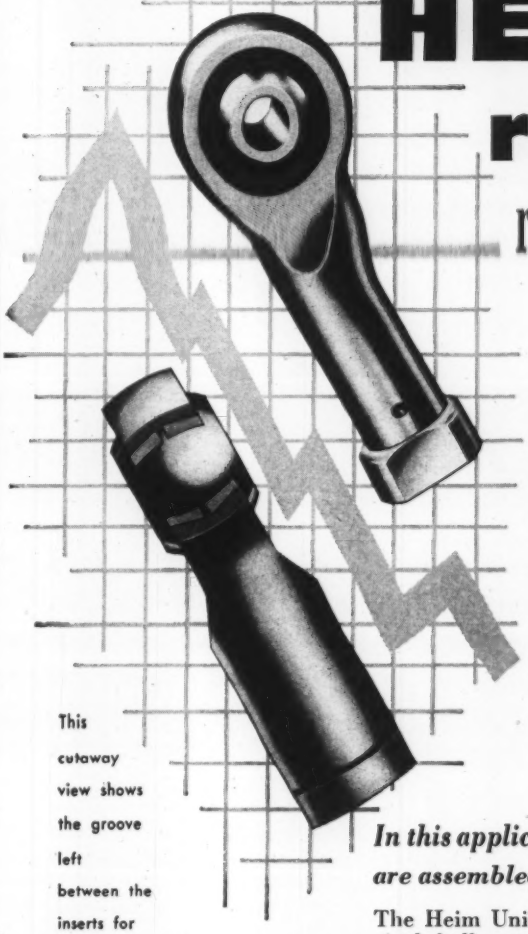
♦

Compact Heat Exchangers. *By W. M. Kays and A. L. London, professors of mechanical engineering at Stanford University; 156 pages, 8¼ by 10¾ inches, clothbound; published by*

HEIM rod ends

reduce cost of material

and assembly time . . .

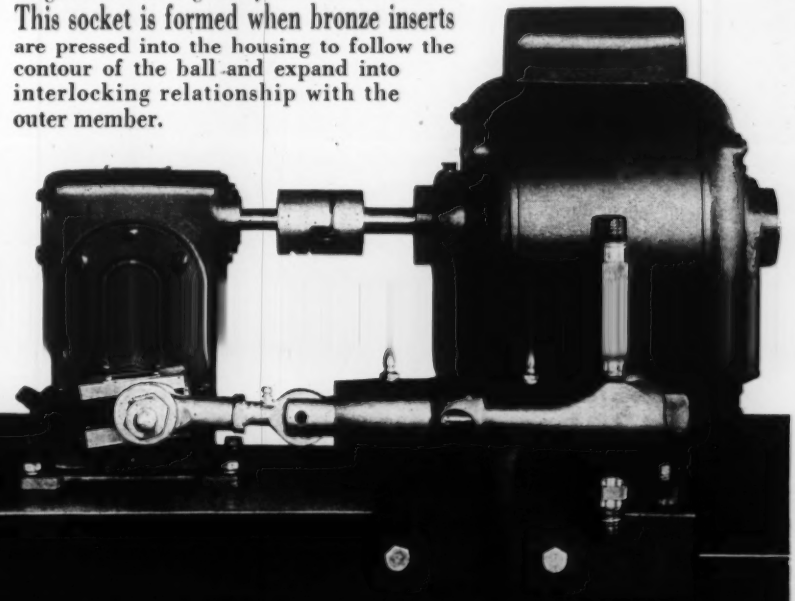


This cutaway view shows the groove left between the inserts for lubrication of the single ball.

The Milton Roy Company, Philadelphia, uses Heim Rod Ends on their Model H-20 Pumps because of overall cost reduction both in material and assembly time. The self-aligning feature of Heim Rod End Bearings eliminates the need for time-consuming *perfect* alignment between the crank arm and the plunger moving in the pump frame.

In this application, one male and one female Heim Rod End are assembled together to form the complete linkage.

The Heim Unibal principle is based on a single ball rotating freely in a bronze socket. This socket is formed when bronze inserts are pressed into the housing to follow the contour of the ball and expand into interlocking relationship with the outer member.



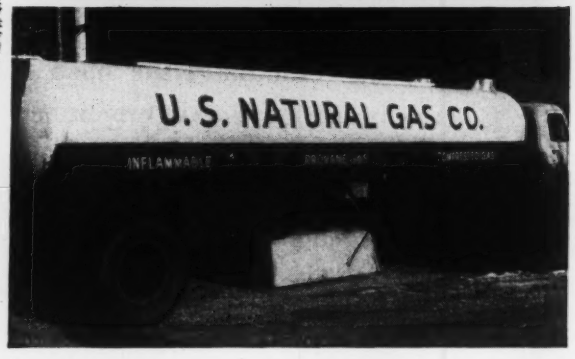
Please write for complete catalog of ***Heim Bearings.***

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

STOW flexible shafting
ON THE JOB

pumping GAS on a tractor-trailer



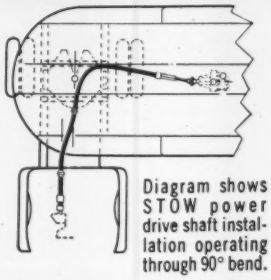


Diagram shows STOW power drive shaft installation operating through 90° bend.

STOW Flexible Shafts have effectively solved power take-off problems on both trucks and tractor-trailers. Large shafts, such as the 1¼" pictured above which transmits up to 10 H.P., have proven their ability on power take-off applications more efficiently and with more trouble-free service...

to operate pumps for petroleum, milk and other liquids; **to operate conveyors** for grain, coal; **to operate compressors** on refrigeration trucks.

Why not put Stow to work on your power drive problems? Stow Engineers are always at your service.

For complete engineering data and illustrations on STOW Flexible Shafting—Write today for FREE Bulletin 525.

Write today for Bulletin 542 and complete data on Power Take-Off drives.

STOW MANUFACTURING CO.
11 SHEAR ST., BINGHAMTON, N.Y.

—ITEM 257—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

The National Press, Palo Alto, Calif.; available from MACHINE DESIGN, $5.00 *postpaid.*

Summarizing 22 reports released since 1948 by the Office of Naval Research, this volume presents the results of experimental and analytical work on compact heat-transfer surfaces.

Types of surfaces considered are tube banks with both inside and outside flow, plate-fin surfaces, finned tube surfaces, and screen and sphere matrix surfaces. A total of 88 surface configurations are considered.

A chapter is devoted to heat-exchanger performance theory and an appendix presents examples of calculations. Another appendix presents the properties of air, water, water vapor and combustion products.

•

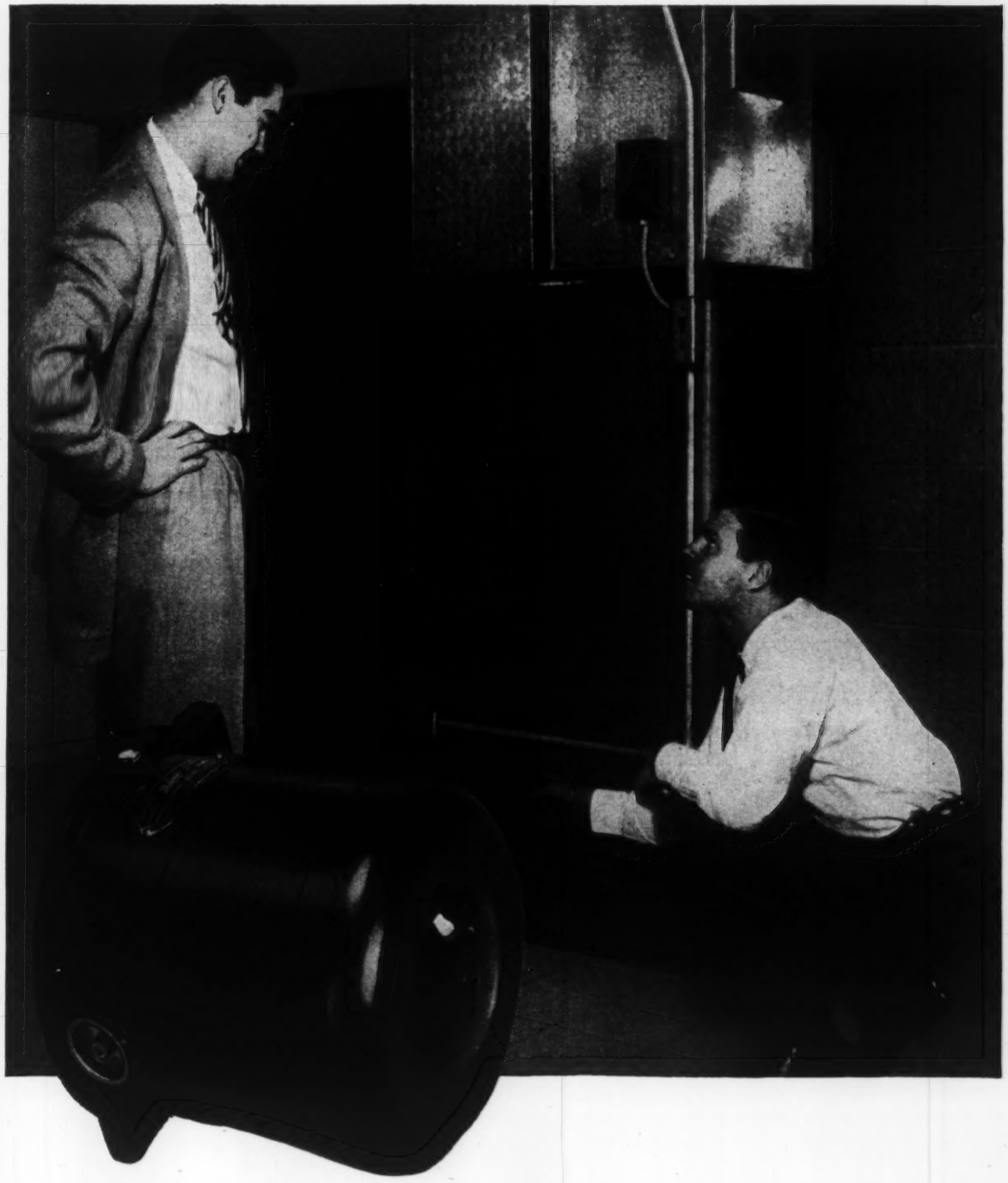
Torque Converters or Transmissions. *By P. M. Heldt; 496 pages, 5⅝ by 8⅜ inches, clothbound; published by Chilton Co., Philadelphia; available from* MACHINE DESIGN, $8.00 *postpaid.*

The subtitle of this book indicates its subjects are "for use with combustion engines in road and rail vehicles, tractors and locomotives." The field is covered in 19 chapters classified in two major groups: hand-operated and automatic transmissions. In this fifth edition only minor changes have been made in the first group. The second group has been brought up to date and particular attention is paid the hydrodynamic torque converter type using planetary gears.

•

An Introduction to the Theory of Aeroelasticity. *By Y. C. Yung, Calif. Institute of Technology; 490 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $10.50 *postpaid.*

The effects of aerodynamic forces on elastic bodies form the subject matter of aeroelasticity. These phenomena are particularly important in aeronautics and sig-



satisfied customers have readymade audiences!

Here's a man who is really happy about his new oil furnace . . . an enthusiastic booster who can hardly wait to tell about it. Chances are that a Packard Electric motor has a lot to do with his satisfaction . . . for Packard motors deliver quiet, dependable, long-lasting performance that's bound to please.

For more than 39 years, Packard Electric craftsmen have been building fractional horsepower motors that lead to one customer telling another. Packard builds a lot of satisfaction into every motor . . . and there's nothing better than a satisfied customer to boost both reputation and sales.

GM GENERAL MOTORS Packard REG. U.S. PAT. OFF. TRADE MARK

Packard Electric Division
General Motors, Warren, Ohio

—ITEM 258—

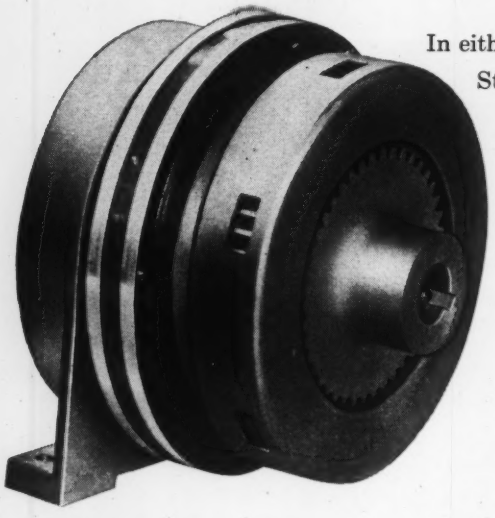
Be Sure with a

Matched-to-the-Machine

STEARNS MAGNETIC CLUTCH

On many machines, a standard magnetic clutch does the job.

On others, however, a special custom-made unit is needed for the most profitable results.



In either case, you're right with Stearns — because this pioneer in magnetic equipment builds both.

Here are important reasons why Stearns magnetic clutches provide positive dependable control on such a wide variety of applications.

- *Torque range from .4 to 30,000 lb. ft.*
- *Low inertia — fast, smooth engage and disengage. Split shaft, through shaft, two speed drives, forward and reversing drives — other special applications.*
- *Quiet and cool running. No metal-to-metal contact, no sparking.*
- *Automatic or manual control.*
- *No toggles, yokes, shifters.*
- *Simple adjustment.*

Let Stearns' design and engineering experience work for you. Consult your Sweet's Product Design File or write for bulletin 226-D.

1083

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC. 692 S. 28th St., Milwaukee 46, Wis.

—ITEM 259—

For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

nificant in other fields. Chapters 2 to 11 contain a survey of aeroelastic problems, basic physical concepts, and the principles of analysis. Chapters 12 to 15 contain the fundamentals of oscillating airfoil theory.

•

Bearing Lubrication Analysis. By *R. R. Slaymaker, professor of machine design, Case Institute of Technology; 108 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$5.00 postpaid.*

Written for the machine designer rather than the lubrication specialist, this book covers the general principles of lubrication analysis in bearing design. In a total of seven chapters, the text deals mainly with sleeve bearings. Subjects included are an outline of hydrodynamic theory, the characteristics of bearing materials, and an analysis of so-called oilless bearings.

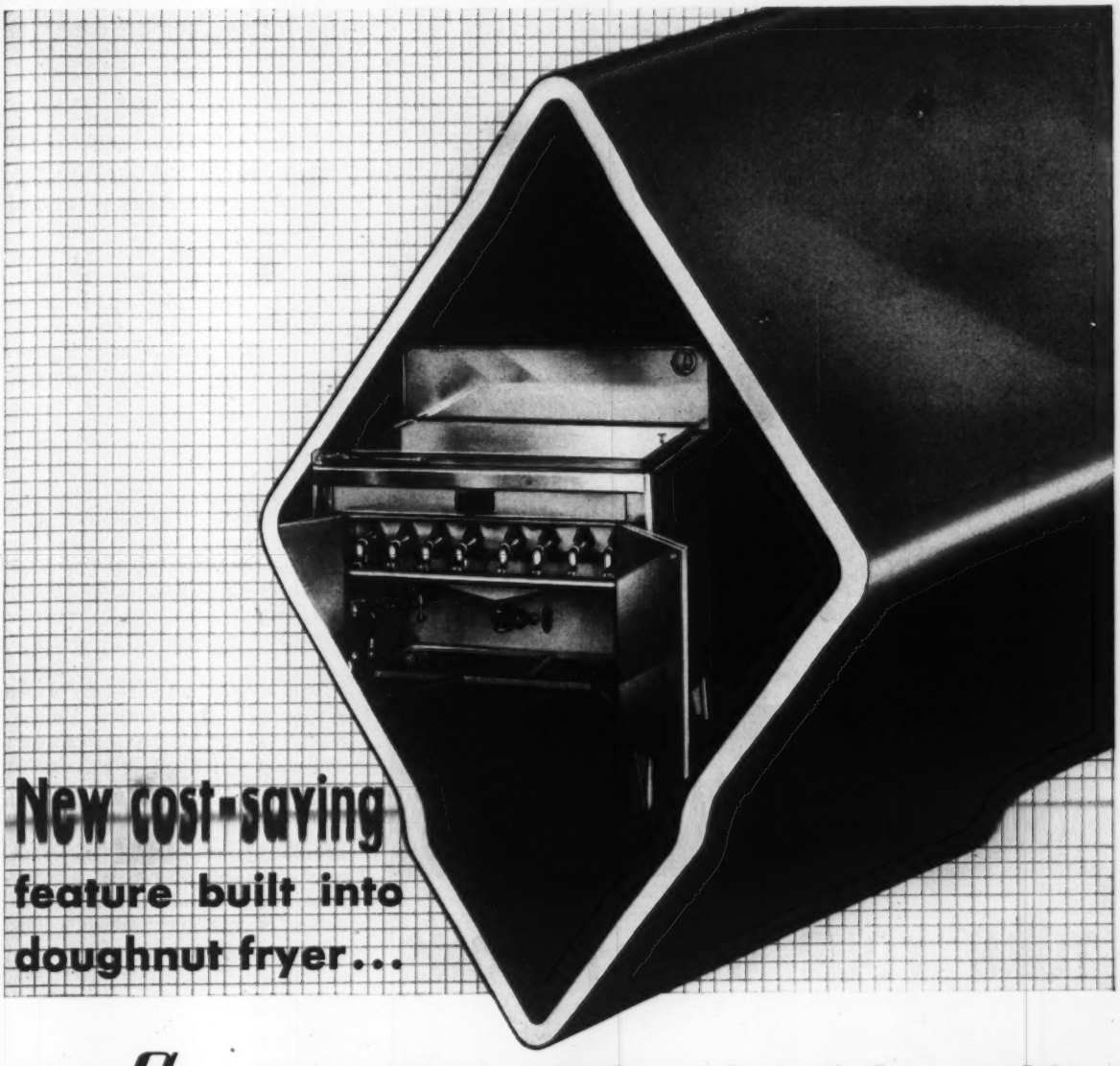
Association Publications

ASTM Specifications for Steel Piping Materials. *432 pages, 6 by 9 inches, paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $4.00 per copy to nonmembers.*

The 1955 edition of this compilation contains the latest approved form of 58 ASTM specifications for ferrous pipes, tubes, castings, fittings and bolting materials. New specifications concern welded pipe for high-pressure service, cold-drawn wrought-iron heat-exchanger tubes, and steel castings normalized and drawn for high-pressure and high-temperature service.

•

Proceedings, Eleventh Annual Meeting, Metal Powder Association. *Vol. I, General Session on Powder Metallurgy, 113 pages, and Vol. II, Electronic Core Session, 199 pages, 6 by 9 inches, paperbound; published by and available from the association, 420 Lexington Ave., New York 17.*



New cost-saving feature built into doughnut fryer...

with *Carpenter* Diamond-Shaped Stainless Tubing

• A new feature in this volume doughnut fryer is the use of super sanitary heating tubes made from diamond-shaped Carpenter Stainless Tubing. The diamond shape permits faster, more economical heating because of the greater heating surface in contact with the fat. Doughnut crumbs cannot settle on the tubes, making cleaning easier and preserving the fat longer.

This is just one more example of combining the inherent advantages of stainless—high strength-weight ratio, fine appearance, corrosion and abrasion resistance and super sanitation—with the extra benefits of special shapes of Carpenter Stainless Tubing. Why not investigate the possibilities of designing and building the advantages of Carpenter Stainless Tubing shapes into your products. Call your nearest Carpenter Distributor or Branch Office for consultation and information.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

Mr. Design Engineer:

Controlled TIMING for your Automatic Machines

This steel-clad Durakool timer-relay has unique construction features that provide millions of cycles with complete dependability. Mechanical life now multiplied 5 to 6 times with the new plunger construction. Pre-set timing, any combination from 0.15 sec. to 20 sec.

See telephone directory for local distributor or write for Bulletin 800

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 Weston Rd., Toronto 9, Canada

FACTORY-SET, TAMPER-PROOF TIMING.

★ Practically fail safe
★ No sticking contacts
★ No maintenance on contacts
★ A Relay and Timer all in one.

Durakool ALL-STEEL MERCURY *Timers*

—ITEM 261—

TURN YOUR OWN PINIONS

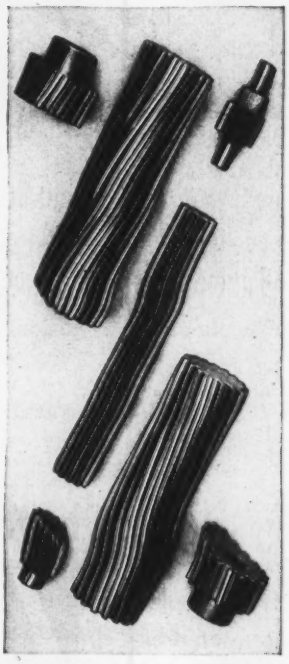
Mass Gear can generate spur, helical and worm pinion rod in all types of material including plastic.

Mass Gear can also produce any type of serrated or special form rod that can be generated.

These rods are available up to 6 feet in length, from 5/32" to 1 ¼" in diameter.

Mass Gear products are made to A.G.M.A. standards, thus insuring uniform quality.

Illustrated brochure showing interesting designs and suggestions available upon request.



G&T Massachusetts Gear & Tool Co.
WOBURN, MASS.

—ITEM 262—

The Engineer's Library

$3.00 *each volume.*

Volume I of these collected papers covers plating of metal-powder parts, machinability of sintered bronze, prealloy steel powders, carbide tooling, small volume production, copper additions to iron, European techniques, and titanium powder metallurgy. Volume II covers specifications and applications of iron powders in electronic cores.

1954 Supplement to the Bibliography and Abstracts on Electrical Contacts. 48 *pages,* 6 *by* 9 *inches, paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,* $1.00 *per copy.*

This booklet is the second of two supplements to the 1952 Bibliography. It contains references on a wide variety of subjects including microphysics of the electric arc, metallurgy of contact materials, mechanics of operating mechanisms, physical and chemical properties of contact materials, and ambient conditions.

Manufacturers' Publications

Forming of Austenitic Chromium-Nickel Stainless Steels. 394 *pages,* 8½ *by* 11 *inches, clothbound; published by International Nickel Co. Inc., available from Direct Mail Circulation Section, International Nickel Co. Inc.,* 67 *Wall St., New York* 5; $5.00 *per copy.*

Extensive and detailed information on the forming of stainless steels was compiled by International Nickel Company with the co-operation of many groups similarly interested in that material. The compilation was first published in 1947. This second edition presents up to date practices on conventional equipment and includes recently developed forming methods.

Chapters cover the mechanical properties of stainless steels, forming characteristics, processing after forming, and forming tools. Other chapters cover the forming of particular shapes.

Its use to achieve product improvement and fabrication economy

What is Mash Welding?

Mash welding is a type of resistance welding used to join the edges of two sheets of metal and produce a flush surface of the near original thickness of one sheet. After completion of the weld, both sheets lie on the same plane. The welded area, minutely thicker, requires only a minimum of finishing.

No gas, flux, or rod is required. Parts to be joined are simply placed between the welding electrodes . . . pressure is applied . . . a flow of current is passed through the piece parts via the electrodes. Natural resistance of the metal parts to the electrical flow creates a heat that causes the metals to fuse at the point of electrode contact.

To demonstrate: Fig. 1 shows the edges of two metal sheets that are to be joined over lapping, approximately the thickness of one sheet of the material. Fig. 2 shows flat faced wheel type electrodes being passed over the lapped edges. The welding current passes either continuously or in a series of closely spaced impulses.

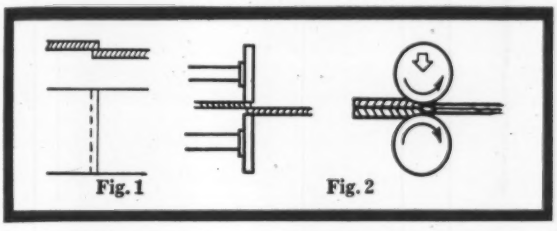


Fig. 1 Fig. 2

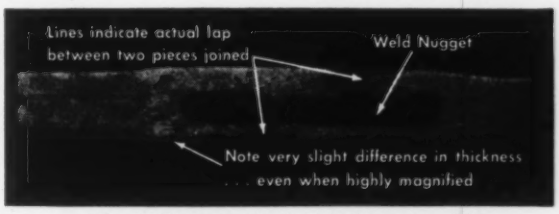

Lines indicate actual lap between two pieces joined
Weld Nugget
Note very slight difference in thickness . . . even when highly magnified

Fig. 3. Macrograph of typical mash weld.

When to Design for Mash Welding

Specify Sciaky "Mash Resistance Welding" whenever you wish a flush joint without a weld bead, rivet heads, or exterior fastening of any kind. Typical applications are tanks and conical shapes where a minimum of exterior finishing is desired. An enlargement of a welded cross-section of a typical piece part application is illustrated in Fig. 3 . . . a strong, yet smooth, metal marriage.

Advantages of Resistance Welding

Production increase and lower operating costs are direct results of the application of Sciaky resistance welding techniques. The simplicity and effectiveness of the Sciaky technique reduces multi-step fastening operations to just one. No skilled workers are required . . . one operator can consistently produce welds suitable to both quality and production requirements.

Sciaky Patented Three-Phase Resistance Welders

Invented, pioneered, and patented by Sciaky, the Three-Phase principle of resistance welding allows a balanced current to be drawn from all three phases of the power supply. The three-phase balanced load, high power factor principle of operation offers direct savings in lower power bills, lower installation costs, smaller distribution lines, and smaller switch gear.

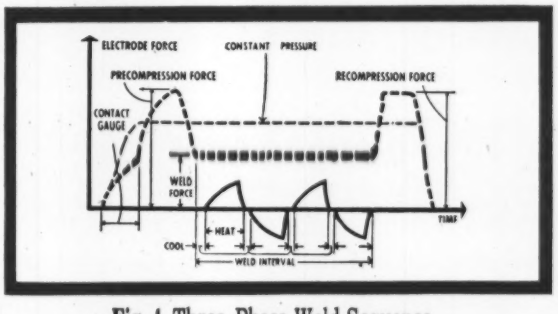


Fig. 4. Three-Phase Weld Sequence.

Sciaky Plans for Tomorrow . . . at their New Research Center

Sciaky's new three-quarter million dollar Research Center is equipped with the most advanced resistance welding machines, testing instruments, and trained personnel devoted to solving *your* joining problems and advancing the application and development of resistance welding. The Research Center invites *you* to submit your fastening design problems.

Build Your Data File with FREE Sciaky Literature

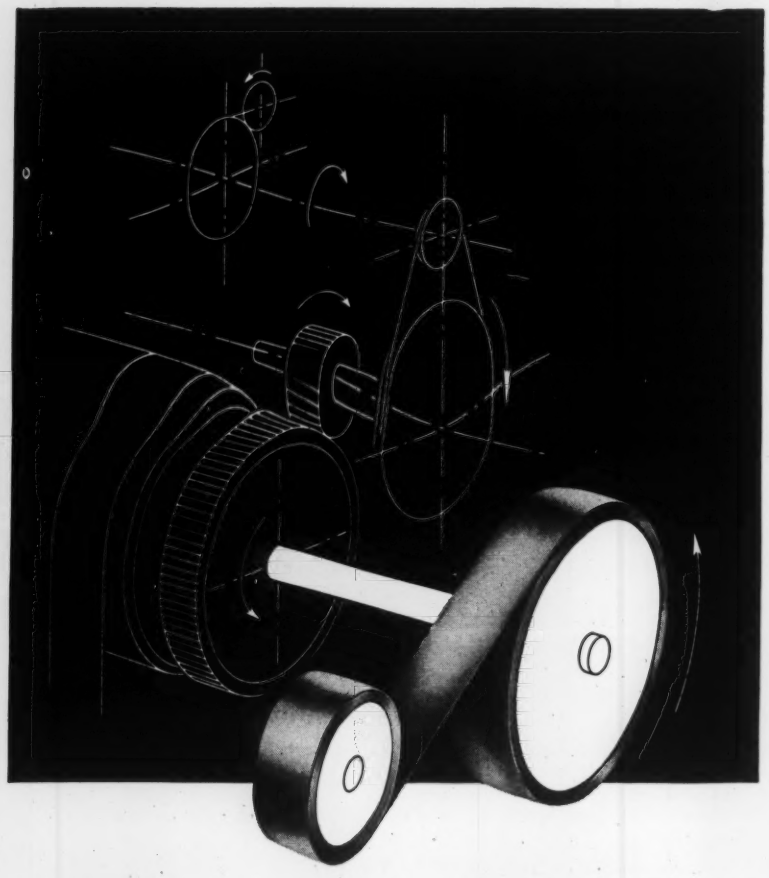
Write today on your company letterhead describing your particular field of interest. We will send suitable back issues (as well as future issues) of our "Resistance Welding At Work" publication, showing typical design problems solved by this method of fastening. All contain impressive case history examples of Sciaky basic thinking—resistance welding techniques designed to do more *useful work* at *lower operating costs with maximum reliability.*

Largest Manufacturers of Resistance Welding Machines in the World

SCIAKY

Sciaky Bros., Inc., 4939 West 67th Street, Chicago 38, Ill., Portsmouth 7-5600

—ITEM 263—



DRIVE IT WITH A NEG'ATOR®

constant-force spring

Ideal for use as a powerful, constant-torque motor is the NEG'ATOR Spring, the revolutionary constant-force spring component which is giving design engineers new ideas.

They're using the NEG'ATOR Spring as a motor in two ways. A light torque motor is made by winding the NEG'ATOR Spring around two drums of unequal size. The tendency of the material to recurl to its *preset curvature* around the smaller drum imparts a constant output torque to the shaft of the larger (output) drum. A more powerful and efficient motor is made as shown above—by *reverse*-bending the free end around the output drum.

Think of how products can be improved, problems solved with a long-running, constant-torque motor. An aircraft designer with a critical counterbalance problem found out. So did a manufacturer of self-retrieving, 50-foot, steel tapes . . . a motion picture camera maker . . . an engineer who developed a new precision mechanical computor . . . many others with drive unit, long deflection, and counterbalancing design problems.

And, so will you when you get the full story. Ask us for a copy of Bulletin 310N, "The Story of the NEG'ATOR Spring." We'll send it immediately without cost.

HUNTER SPRING COMPANY

3 Spring Street, Lansdale, Pennsylvania

(near Philadelphia)

SPRINGS • STAMPINGS • TEST APPARATUS

—ITEM 264—

For More Information Circle Item Number on Yellow Card—page 19

New Machines

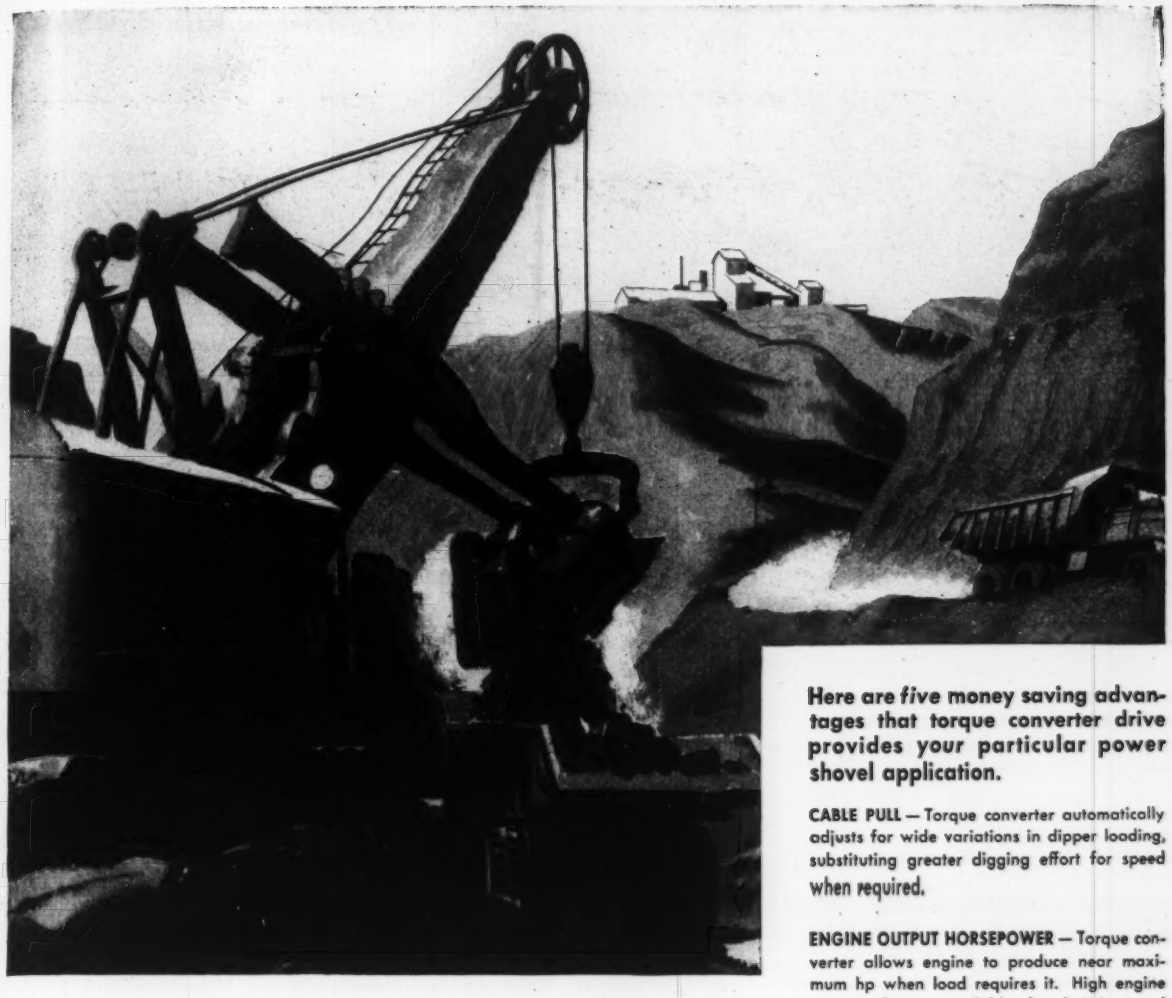
Domestic and Commercial

Air Conditioners: Units designed for residential and small business applications are available in 2, 3 and 5-ton capacities. Insulated cabinets contain filters, cooling coil, thermostatic valve, centrifugal blower and motor. Refrigeration is furnished by a compressor which may be located remotely. The units are adaptable for use with city or tower water and evaporative or air-cooled condensing units. *General Motors Corp., Frigidaire Div., Dayton, O.*

Ice Flaking Machine: Chip-Freeze automatic unit produces 560 lb of ice daily. Ice flakes are removed at waist level from the lower part of the upper section of the storage bin, and new ice is produced at the top of the unit. The mechanism is accessible from front and rear, and operates automatically as ice is used. Design incorporates low-pressure cutout protection in the event of temporary interruption of the water supply system. Well-ventilated compressor provides good air circulation in warm temperatures. Storage capacity is approximately 200 lb. Floor space requirement is 30 x 24 in. Units are available in five pastel colors in addition to white. *Shelley Industries, Cold Corp. of America Div., Chicago, Ill.*

Rotary Lawn Mowers: Redesigned Whirlwind 18 and 20-in. machines have staggered wheels, a muffler for quiet operation, and an aluminum housing for improved cutting and leaf mulching operations. Clippings are distributed evenly through a front discharge chute. Average cutting capacity is 23,000 sq ft with a 2-in. overlap at 3 mph. The unit is powered by a 2-hp engine. Standard starter is of the recoil type. Plug-in electric starter, optional on the 20-in. unit, operates on 110-v circuit. *Toro Mfg. Corp., Minneapolis, Minn.*

Water Chiller: Flow-Pac unit is designed for residential air conditioning and small industrial appli-



$750 SAVED IN ONE SEASON

using Torque converter on power shovel

A prominent contractor recently reported that he saved $750 in one season using a Twin Disc *Three-Stage* Torque Converter on one of his power shovels.

This total was comprised of savings on three different phases of the shovel's application. (1) Cable—on two shovels with direct drive, cables were replaced *seven times* on one and *eight times* on the other. With torque converter drive, however, the cable was replaced *only three times*. Resultant saving: $350. (2) Maintenance costs — a saving of 12½ cents per hour, or a season total of $250 on the shovel with the Twin Disc Converter. (3) Fuel consumption — the torque converter unit used ½ gallon less fuel per hour, saving $140 in the 2,000 hour season.

You can realize a *similar* saving from *your* power shovels. *Specify* Twin Disc Torque Converters for your new units or *install* them in your existing equipment. For full details see your equipment or engine distributor. Write for bulletin 135-D.

All facts in the above story are contained in an actual case history. We have not identified the operation because publishing the owner's name would reveal confidential information.

Here are *five* money saving advantages that torque converter drive provides *your* particular power shovel application.

CABLE PULL — Torque converter automatically adjusts for wide variations in dipper loading, substituting greater digging effort for speed when required.

ENGINE OUTPUT HORSEPOWER — Torque converter allows engine to produce near maximum hp when load requires it. High engine power always available for hoisting and crowding.

ENGINE SPEED — Torque converter provides high engine speed throughout its working range, and higher hp output is available for heavy digging and hoisting loads. Converter equipped engine can't lug. Heavy overloads will not kill the engine.

LOWER MAINTENANCE COST—Torque converter reduces peak loads throughout shovel drive train. Cushioning shocks increases wear life for most parts subject to fatigue failure.

LONGER CABLE LIFE — In proved installations, even frayed cables with short life expectancy have been known to last a year or more where a torque converter has provided smooth, sustained output power.

TWIN DISC

CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC

Torque Converters

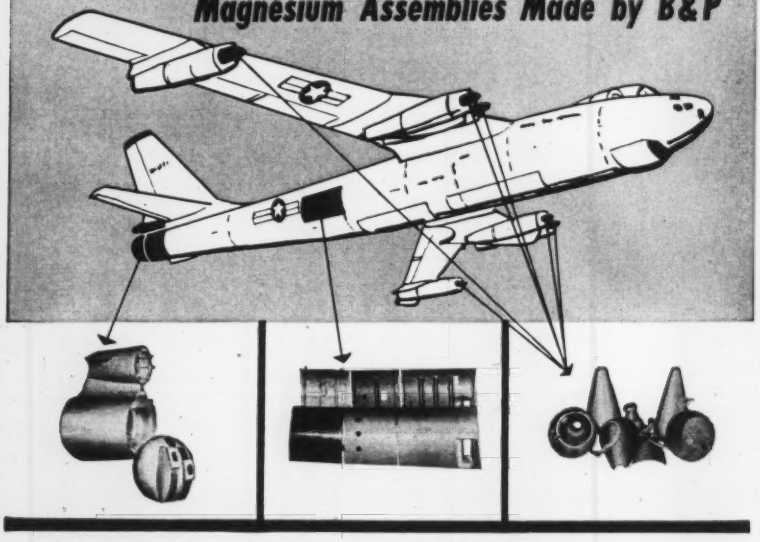
TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND . DALLAS . DETROIT . LOS ANGELES . NEWARK . NEW ORLEANS . TULSA

—ITEM 265—

IN THE BOEING B-47 BOMBER:

Magnesium Assemblies Made by B&P



Tail cone and gun turret enclosure are supplied by B&P to General Electric Co.; smooth panel doors made for Lockheed and Douglas B-47 production; and the inboard and outboard jet pods for Bell Aircraft Co. In addition, B&P produces magnesium cases and components for electronics systems in the B-47 and many other military planes.

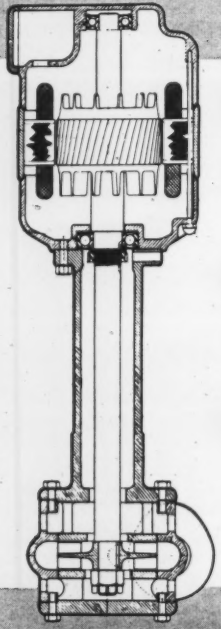
Write for folder describing B&P's facilities for magnesium and titanium work.

BROOKS & PERKINS, INC. 1940 W. Fort St. Detroit 16, Mich.

Offices in New York, Washington, Los Angeles and Dallas

—ITEM 266—

Take a Good Look AT THE Ruthman Gusher Coolant Pumps



SIMPLE DESIGN

Gusher Coolant Pumps are designed so that they require no packing, foot or relief valves. They consume less power when throttled and there is no metal-to-metal contact in the pump, insuring long life with minimum attention.

RUGGED CONSTRUCTION

All castings have been strengthened through time-tested operation. The one-piece shaft is precision ground, which rotates on heavy-duty precision ball-bearings.

DEPENDABLE PERFORMANCE

The entire rotating shaft is dynamically balanced to eliminate vibration and wear. Pre-lubricated ball-bearings with surplus grease pocket require no further attention. Your Gusher is always primed . . . ready to deliver coolant in a split second.

THE RUTHMAN MACHINERY CO.

1811 Reading Road Cincinnati, Ohio

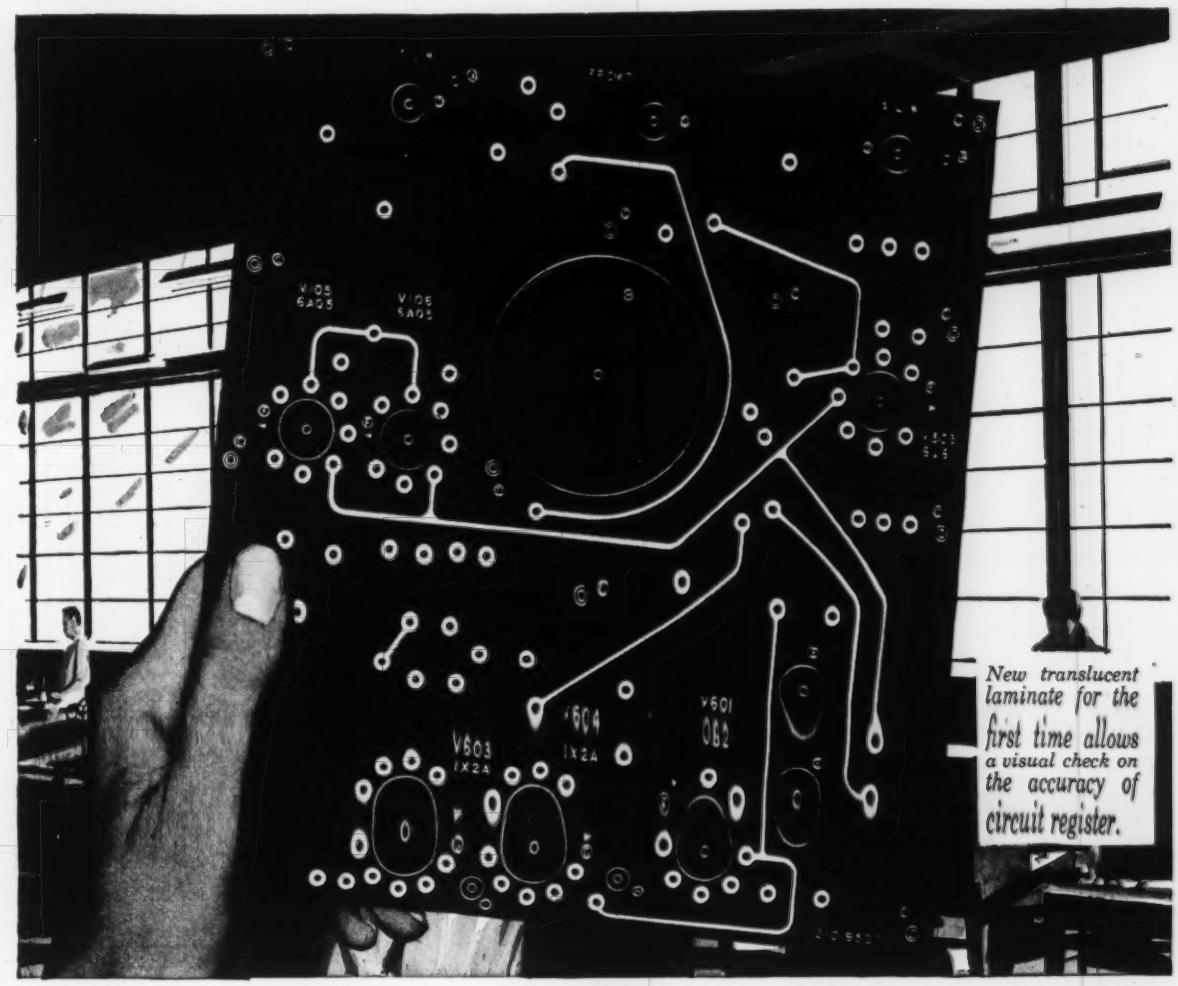
—ITEM 267—

cations. It can be used with all types of chilled water convectors or with water coils in central air handling systems. Units are available in 1¾, 3, and 5-hp models, with either water or air-cooled condensers. Spring-mounted compressor assures quiet operation. Unit design also incorporates full insulation, copper water connections in the chiller unit and a sealed refrigerant system. The 3-hp model, with heat transfer rating of 36,000 Btu per hour, occupies a floor space of 24 x 10 in. and is 27 in. high. *Acme Industries Inc., Jackson, Mich.*

Metalworking

Tube Sheet Drill: Automatic, high-speed unit drills holes on tube sheets of ferrous and nonferrous materials used on heat exchangers, condensers, evaporators and heaters. It accommodates materials with diameter to 6 ft and thickness to 10 in. Thinner sheets and baffles can be drilled in stacks up to 10 in. thick. Holes are accurately drilled and can be on closely spaced centers with selected patterns. Load meters for the two drilling head motor drives indicate drill sharpness and hard spots in the material. Meters can be set to retract the drill under instantaneous or continuous overload conditions. Travel and feed and speed rates of each head can be adjusted individually. Micrometer adjustments are provided for movements to nonstandard hole locations. Heads have four speed selections and variable hydraulic feeds. Drill spindles accommodate No. 40 milling machine tapers and can be provided with easily changeable tool holders. Maximum table travel is 10 ft, and work area is 6 x 2 ft. *Walter P. Hill Inc., Detroit, Mich.*

Brake Cylinder Machine: Five-station vertical machine automatically drills, chamfers, spot faces, hollow mills and taps brake cylinders. It processes four cylinders simultaneously at a rate of 1028 per hour at 100 per cent efficiency. Thrust cylinder is mounted in front of the hardened and ground ways, in the center of the thrust load. An electric motor drives the upper drill head through a splined shaft. The lower drill head has eight



New translucent laminate for the first time allows a visual check on the accuracy of circuit register.

Formica Research perfects sensational new cold punching laminate

with valuable translucency properties and 1,000,000 megohms IR after 96 hours at 95° F and 90% relative humidity . . .

Research, an important part of the exclusive new Formica 4-point service, has just perfected a new cold punching paper base laminate offering 1,000,000 megohms insulation resistance and valuable new translucent properties.

Known as XXXP-36, the new grade brings greater accuracy to printed circuitry. Because of its cold punching qualities, XXXP-36 requires no heat cycle. Therefore, the base laminate is not subject to dimensional change as in grades which must be heated before punching. This means that with Formica XXXP-36, you can now produce printed circuits with new and higher standards of accuracy.

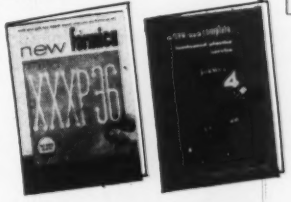
XXXP-36 translucency can be doubly useful. Make this simple test: hold it to the light. You can see (1) the smooth, homogenous structure, the total absence of resin pockets, voids and imperfections that dissipate the insulating properties of ordinary paper base laminates . . . and (2) how perfectly the circuit on one side registers with that on the other. New XXXP-36 can be used for applications other than printed circuits. Formica's engineering skill can help you find new materials for new products and processes. For complete information on the new XXXP-36, or on the new "Formica-4" service, use coupon below.

The Formica Co., 4545 Spring Grove Ave., Cincinnati 32, Ohio.

Industrial
FORMICA®
Laminated Plastic
Pays in Performance

FORMICA®—*the most famous name in laminated plastics—Engineered for industry, Beauty Bonded for the home.*

Make the Formica Translucency Test. Send for a sample XXXP-36 printed circuit. Fill out and mail coupon today.



Gentlemen:

☐ *I'd like a sample XXXP-36 printed circuit and complete information on this new grade.*

☐ *Send bulletin showing how I can take advantage of the new "Formica-4" laminated plastics service.*

Name_____

Company_____ Title_____

Address_____

City_____ Zone___ State_____

—ITEM 268—

spindles and produces a positive chamfer. It is driven by a 5-hp hydraulic motor. Three stations have pot-type heads which can be replaced without removing the platen. *LaSalle Tool Inc., Detroit, Mich.*

Milling Machine: Vertical unit provides feed rates from 80 to 570 rpm in the low-speed range, and 584 to 3800 rpm in the high-speed range without belt changes. Speed rate is indicated by a built-in tachometer. A positive clutch in the center of the quill hand provides quill feed control. Dovetailed ways provide a rigid clamping surface 16 in. long. The 1½-hp, three-phase motor is mounted in the base of the machine. Working surface of the ground table is 36 x 9 in. The machine has 18 in. longitudinal, 10 in. cross, and 16⅝ in. vertical travel. The head, which can be swiveled 360 deg, rotates on a rigid sleeve mounting. *Logan Engineering Co., Chicago, Ill.*

Processing

Coaxial Lead Former: Automatic unit cuts and forms coaxial leads of resistors, capacitors, diodes, coils and similar components to any length or shape at a rate of 5000 or more parts per hour. Available in three models of two, four or six slides, depending on final lead shape desired, the machine is pneumatically operated and electrically controlled. Normally components are manually chute-fed to the machine; card, roll or hopper feeds are also available. Slides operate in pairs on the clamped leads to form them into desired shapes. Slides and ways are hardened and ground. Lead length and loop size are changed by moving slides along a scale having 1/64-in. graduations. The machine accommodates components up to 2½ in. long and 1 in. diam. Size of the unit is 25 x 30 in., and its weight is 89 lb. *Design Tool Corp., New York, N. Y.*

Heat Treating Unit: Gas-powered turntable unit performs brazing, soldering, annealing and hardening operations on small parts. Workpieces are held by fixtures attached to a power-driven turntable and passed between two rows of burner nozzles as the turntable revolves.

When steel is 3 times stronger than iron . . .

Has two and one-half times the rigidity . . .

Yet costs a third as much per pound . . .

WHY aren't more of your products designed for welded steel

Ask
THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio

Creating lower costs for industry . . . with welded steel

—ITEM 269—

Endurance Rated
COUNTERS
to Fit every need

200 MILLION COUNT LIFE

PIC
Silver King Stroke Counters

Unequalled for Automobile and Aircraft factories; stamping, metal working, die casting and plastic molding machines; laundry, printing and all kinds of equipment.

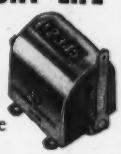
6 MILLION COUNT LIFE

PIC
Junior King

The proven answer for office machines, amusement machines, and factory equipment where service is moderate.

3 MILLION COUNT LIFE

PIC
SMX Tamperproof



Millions used for vending machines and other equipment where space is limited.

200 MILLION COUNT LIFE

PIC
Silver King Revolution Counter

For measuring machines, metering equipment, etc. Available with flexible shaft for convenient location.

1 BILLION COUNT LIFE
10,000 CPM

PIC
Clipper Coil Winding Counter

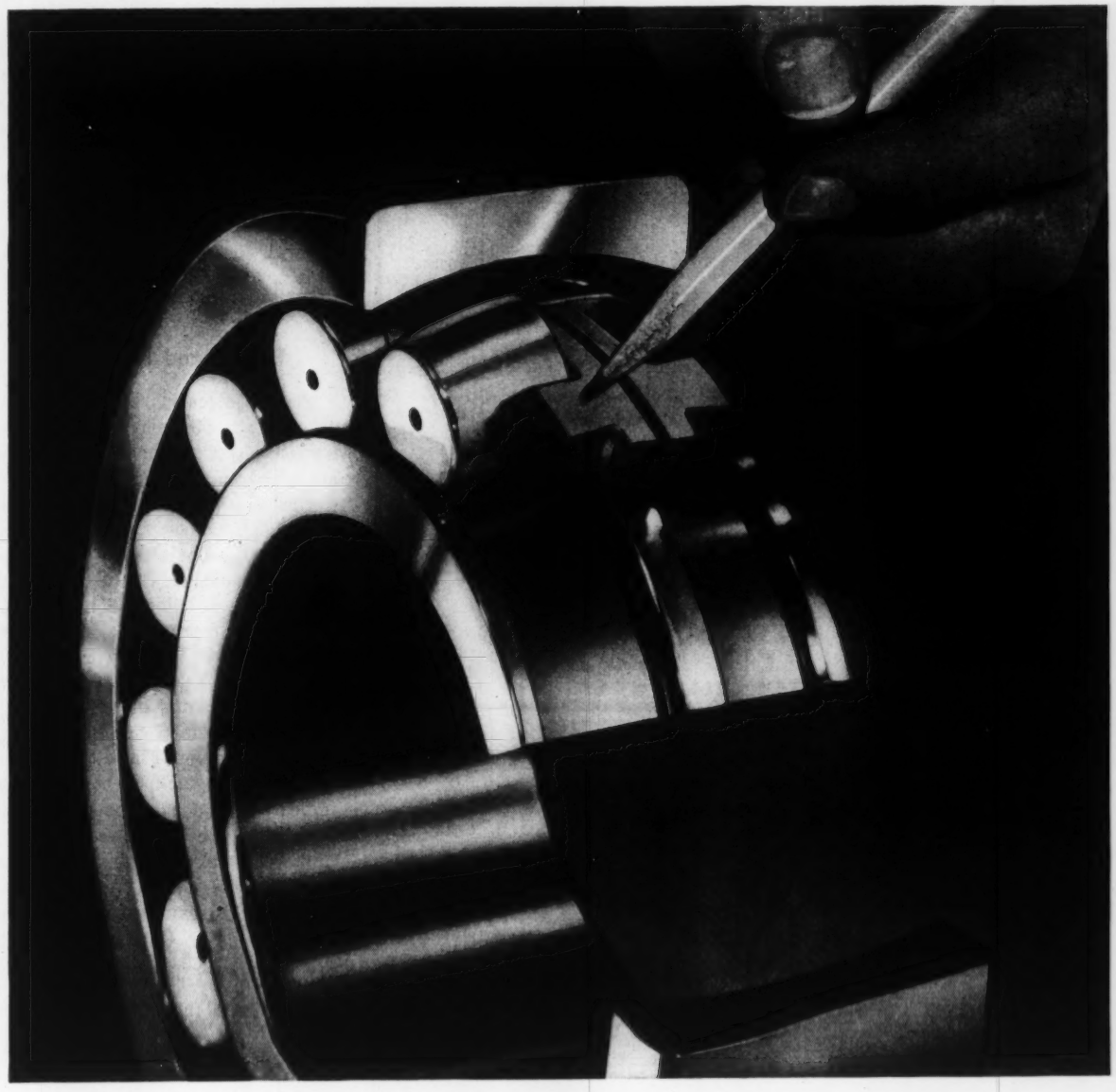
Unequalled for high speed coil winding.

See your PIC Representative or write.

PIC
PRODUCTION INSTRUMENT CO
702-08 W. Jackson Chicago 6, Ill.

—ITEM 270—

TORRINGTON *SPHERICAL ROLLER* BEARINGS



Land-riding cages for longer life!

These fully machined cast-bronze, land-riding cages—one for each path of rollers—are important performance builders in TORRINGTON'S Spherical Roller Bearings. The one-piece retainers keep the rollers perfectly aligned at all times, even under conditions of shock load and sustained speeds. Lubrication is more effective, too, as the lubricant has easy access to vital points of contact between rollers and races.

This feature is typical of TORRINGTON'S design, made possible through long experience in serving industry with the finest in precision bearings. That's why it pays to look to TORRINGTON first when your application calls for Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

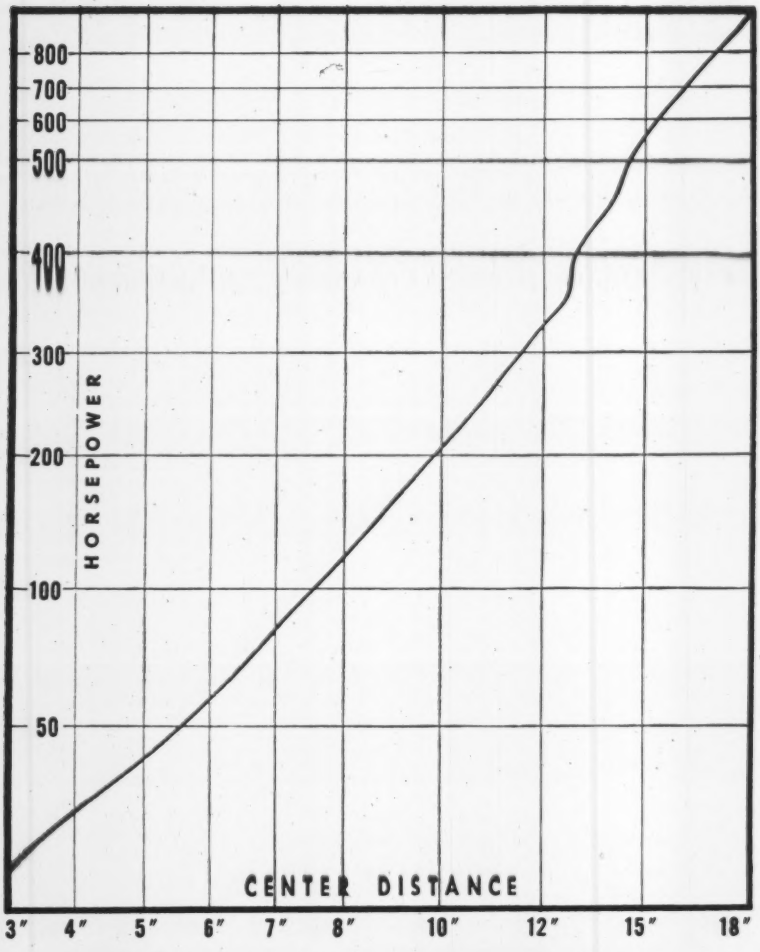
THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1865–1955

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

—ITEM 271—



WE LEFT COMPETITIVE RATINGS OUT OF THE CHART PURPOSELY..

. . . because we think the load-carrying capacity of Cone-Drive speed reducers is pretty impressive all by itself. Then, we've also got a lot of friends in the worm gear speed reducer business. And they make pretty fair reducers themselves.

Two things are responsible for the high capacity of Cone-Drive speed reducers. First, we use extra-heavy gears mounted on oversize taper roller bearings in reinforced, heavy housings. Extra "beef' alone accounts for part of our capacity.

Even more important, however, is the Cone-Drive double-enveloping worm gear design. Here, we literally wrap worm and gear around each other to put ⅛ of all teeth in continuous full-depth contact. This results in spreading tooth contact over a greater area, reducing pressure on individual teeth, increasing load capacity and life of the gearing.

Ask for Bulletin 600C without obligation.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

—ITEM 272—

New Machines

Valve adjustment on the burner manifold controls heat input. Heating time is variable by an adjustable speed drive on the turntable which provides ¼ to ½ or ½ to 1½ rpm. Burner nozzles are mounted with flexible copper tubing. Burner manifold is adjustable vertically and horizontally. The unit burns manufactured, mixed, natural, propane or butane gas. Size is 36 x 30 x 30 in. *Gas Appliance Service Inc., Chicago, Ill.*

Testing and Inspection

Flaw Detector: Ultrasonic Inspectogage 55 performs nondestructive testing for flaws in metals, glass and nonfilled plastics. The device gives visual indications of material thickness and requires access to only one side of the work. The unit consists of an oscillator, cathode ray oscilloscope and transducer which transmits ultrasonic vibrations into the tested material. A vertical marker on the face of the tube indicates the exact thickness of material by pointing to a calibrated screen. Flaws due to discontinuity or lack of bonding are indicated by a shift or disappearance of the thickness reading. The unit weighs about 50 lb, and power requirement is 115 v, 60 cycles. Search units scan four ranges from 0.025 to 0.3-in. Calibrated screens for the four ranges are provided; other ranges are available. *Alcar Instruments Inc., Little Ferry, N. J.*

Environmental Test Chambers: Redesigned Weather-Lab test chambers are available in four sizes with working space from 10 to 40 cu ft and for supplying temperatures from 30 to 200 F and relative humidity from 20 to 95 per cent. Tests can be conducted on paper, foods, packaging materials, preservatives, mold and fungus growths, in addition to MIL and JAN government tests. Units are of stainless steel construction, have built-in refrigeration, lights, wet and dry bulb thermostats, electric heaters and blowers. Insulation is vapor-sealed. A single door is provided on the 10 cu ft model; other models have double doors. *Labline Inc., Hudson Bay Co. Div., Chicago, Ill.*

—ITEM 272—
For More Information Circle Item Number on Yellow Card—page 19

REPRINTS AVAILABLE FROM MACHINE DESIGN

Multiple-Circuit Switches

lever – rotary – push or pull

by Keith A. Carlson
Associate Editor, MACHINE DESIGN

A design manual on the factors to be considered in the selection and application of multiple-circuit switches.

Part One—discusses physical and electrical characteristics of lever-operated switches

Part Two—discusses physical and electrical characteristics of rotary switches

Part Three—discusses physical and electrical characteristics of push or pull switches

Part Four—discusses factors to be considered when selecting switches from these types for a specific application

---

How to select and apply

Electrical Connectors

by Laurence D. Shergalis
Assistant Editor, MACHINE DESIGN

Separable electrical connectors can often help satisfy several design objectives—convenience, portability or mobility, flexibility. Connectors provide these features in two kinds of circuits—power and signal.

Part One—discusses how to select and apply Electrical Connectors for power circuits

Part Two—discusses how to select and apply Electrical Connectors for signal circuits

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SEND ME____copies of "MULTIPLE CIRCUIT SWITCHES" at $1.00 per copy

____copies of "ELECTRICAL CONNECTORS" at $1.00 per copy

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TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

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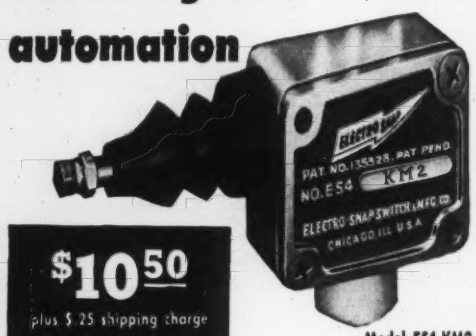
(Add 3% to orders for delivery in Ohio to cover state sales tax)

ELECTRO SNAP

ONE-WAY IMPULSE SWITCH

with exclusive advantages for automation



$10.50
plus $.25 shipping charge

Model ES4-KM2
½ actual size

ELIMINATES INTERLOCKING SWITCHES AND COMPLICATED ACTUATING DOGS

Ideal for pulsing solenoid valves on air-hydraulic controls, sequencing circuits, etc., because it allows other controls to reverse or operate the same circuit. Switch sends a short electrical impulse and then switches itself out of the circuit.

GIVES MORE DEPENDABLE CONTROL

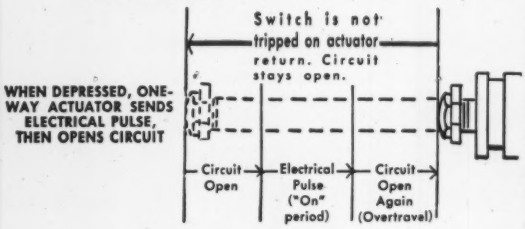
Switch replaces timers, relays, and troublesome one-way dogs to simplify circuits — cuts chances for failure. No delicate adjustments.

LOWERS COST OF CONTROL CIRCUITS

Impulse switch costs less than complicated control devices it replaces. Fewer switches are required for sequencing. Simple mounting.

SPEEDS UP AUTOMATIC OPERATION

Automatic machines can run faster because cycles can be more closely sequenced. There's no delay due to timer tolerances or extra machine motions to actuate interlock switches.


Switch is not tripped on actuator return. Circuit stays open.
WHEN DEPRESSED, ONE-WAY ACTUATOR SENDS ELECTRICAL PULSE, THEN OPENS CIRCUIT
Circuit Open
Electrical Pulse ("On" period)
Circuit Open Again (Overtravel)

SPECIFICATIONS

UL rated at 10 amps/125v AC Movement Dif. 0.020"
Operating Force 3½ lbs.

Model No.	Overtravel	"On" Period (inches of actuator travel)
ES4-KM1	3/8"	1/16"
ES4-KM2	5/16"	1/8"
ES4-KM3	1/4"	3/16"
ES4-KM6	1/16"	3/8"

TRY ON YOUR CONTROL JOB — ORDER NOW

Send Your Standard Purchase Order
Specify Model Wanted—Discounts on Quantity Purchases

ELECTRO SNAP

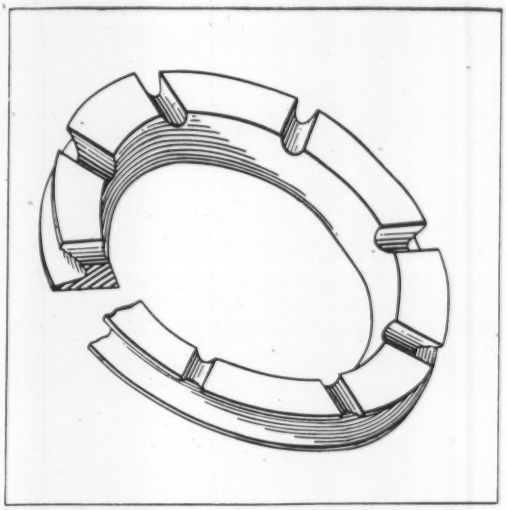
ELECTRO-SNAP SWITCH & MFG. COMPANY
4214 West Lake Street, Chicago 24, Illinois

—ITEM 273—

NOTEWORTHY Patents

Pressure-Balanced Seal

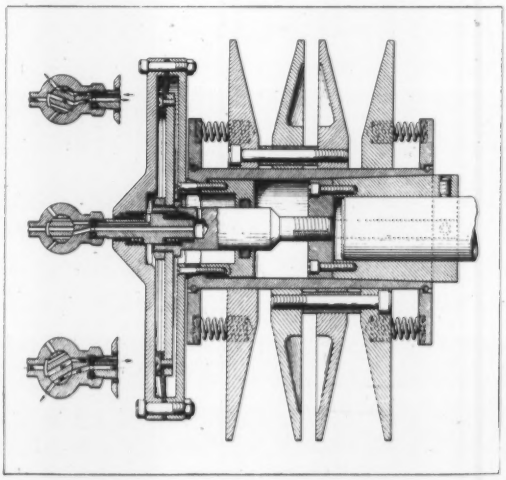
Radial grooves in one face of a rubber shaft seal permit fluid pressure to act on both faces of the seal. A balance resulting between the radial inward and outward fluid pressures on the seal eliminates fric-



tional drag variations between the seal and the rotating shaft. Engagement of the seal against the shaft is maintained by a garter spring fitted into a groove in the circumference of the seal. *Patent 2,707,118 assigned to Linear Inc. by J. H. Swartz and H. M. Purcell.*

Pneumatic Speed Control

Adjustable-pitch sheaves are locked in place after adjustment by a pneumatically-controlled motor. Diameter of a tapered, split hub on which the spring-loaded sheave flanges are mounted is controlled by means of a mating tapered sleeve connected to the motor diaphragm. When the motor is operated to



For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 274→

announcing Accopac N-820:

a dense fiber gasket for high bolt loads at temperatures up to 250°F.

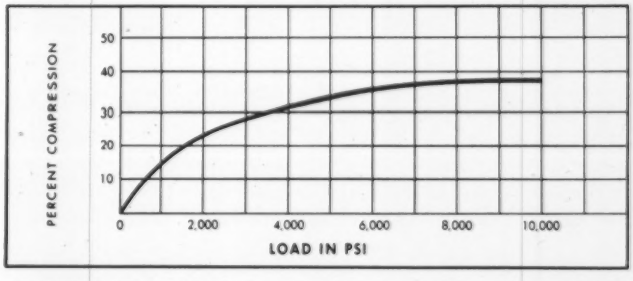
Accopac® N-820 is a new beater-saturated gasket material designed for applications where a combination of heat and pressure may cause conventional plant fiber materials to fail. For example, N-820 is an economical replacement for sheet asbestos packing in applications involving bolt loads of 2,000 psi and upward and where temperatures do not exceed 250° F.

Here's why N-820 can be used successfully in these tough jobs:

High density: N-820 is much more dense than previously available fiber sheets. It withstands test pressures up to 100,000 psi without crushing. N-820 conforms well to flange surfaces and maintains torque much better than softer materials saturated by ordinary methods.

Non-extractable binder: N-820 has no volatile binder which could be lost at temperatures up to 250° F. Its sealing properties are not affected by the leaching action of contained fluids or by alternately wet-and-dry applications. Shrinkage due to binder loss is eliminated with N-820.

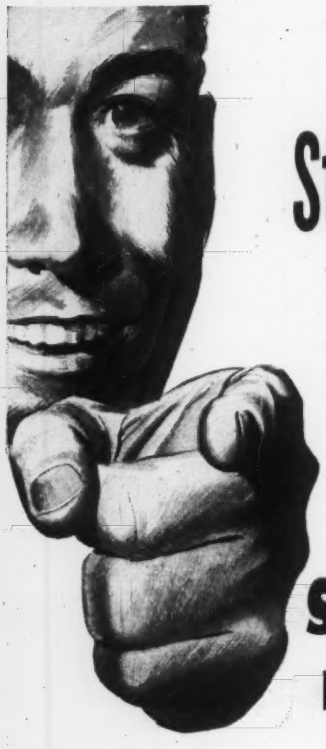
N-820 is the newest member of the Armstrong Accopac family, and it's already being used in many heavy-duty applications in place of more expensive materials. If you'd like more information about Accopac N-820, write for samples and data sheet to Armstrong Cork Co., Industrial Division, 7002 Dean St., Lancaster, Pa.



COMPRESSIBILITY. N-820, less compressible than other Accopac materials, is recommended for heavy-duty applications where flange pressures will be 2000 psi or more and where temperatures do not exceed 250° F.

Armstrong ACCOPAC

. . . used wherever performance counts



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Industry across-the-board is solving problems, and *cutting costs*, with Silicone Rubber Parts. From access door seals on research rocket planes probing the heat barrier . . . to gaskets for kitchen range oven doors, they are providing the answer. Time and again **Silicone Rubber Parts are replacing** costly metal constructions forced upon design engineers by the limited thermal stability of organic rubbers.

Because new compounds now retain desirable rubber-like properties at temperatures from −130°F. to +600°F., they play ever-increasing roles in the aviation, automotive, electrical and chemical industries.

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Parts made from Silicone have excellent dielectric properties and resist compression set, weathering, ozone, oxidation, hot lubricating oils and many chemicals. They can be covered with (or bonded to) a number of synthetic or other materials to provide greater strength or wearing qualities. Let STALWART show you how Silicon Rubber can *cut* your fabrication costs.

6651-SR

STALWART RUBBER COMPANY

180 Northfield Road Bedford, Ohio

For complete information, write today for Catalog 56SR-3

—ITEM 275—

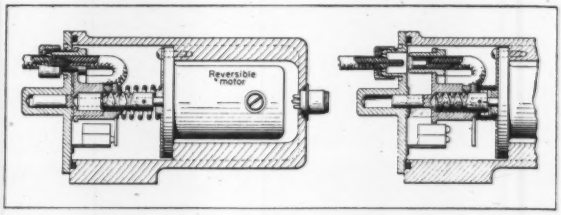
For More Information Circle Item Number on Yellow Card—page 19

Noteworthy Patents

expand the split hub, it locks the flanges against axial movement to maintain the pitch diameter adjustment. When the hub is allowed to contract, the sheave flanges are free to adjust position according to belt tension. A three-way pneumatic control valve is utilized to actuate the pneumatic motor. *Patent 2,709,373 assigned to American Pulley Co. by J. T. Barron.*

High-Voltage Switch

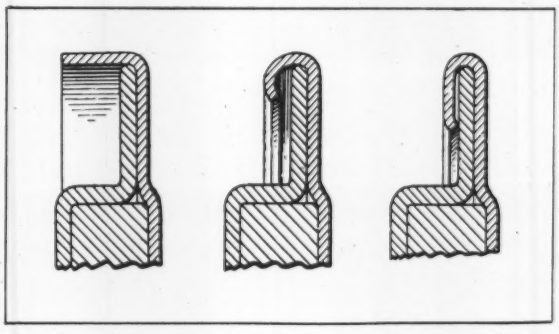
Telescoping contacts assure high insulation effectiveness in a motor-driven high-voltage switch. A jumper mounted on a movable carrier is designed to connect a common contact with one of two other electrical contacts. When the switch drive motor is actuated, its helical-grooved shaft, on which the jumper carrier is mounted, pulls the jumper out of the stationary contacts, disconnecting the circuit. As the carrier reaches the end of its travel, a stop forces it



to swing through a predetermined arc into position to connect the other contact with the common contact. Upon reversal of the motor, the jumper carrier moves forward, engaging the jumper with the contacts and energizing a second circuit. Limit switches can be employed to automatically stop or reverse the drive motor. *Patent 2,709,725 assigned to Airtron Inc. by C. E. Bieber and R. S. Carr.*

Antifriction Bearing Seal

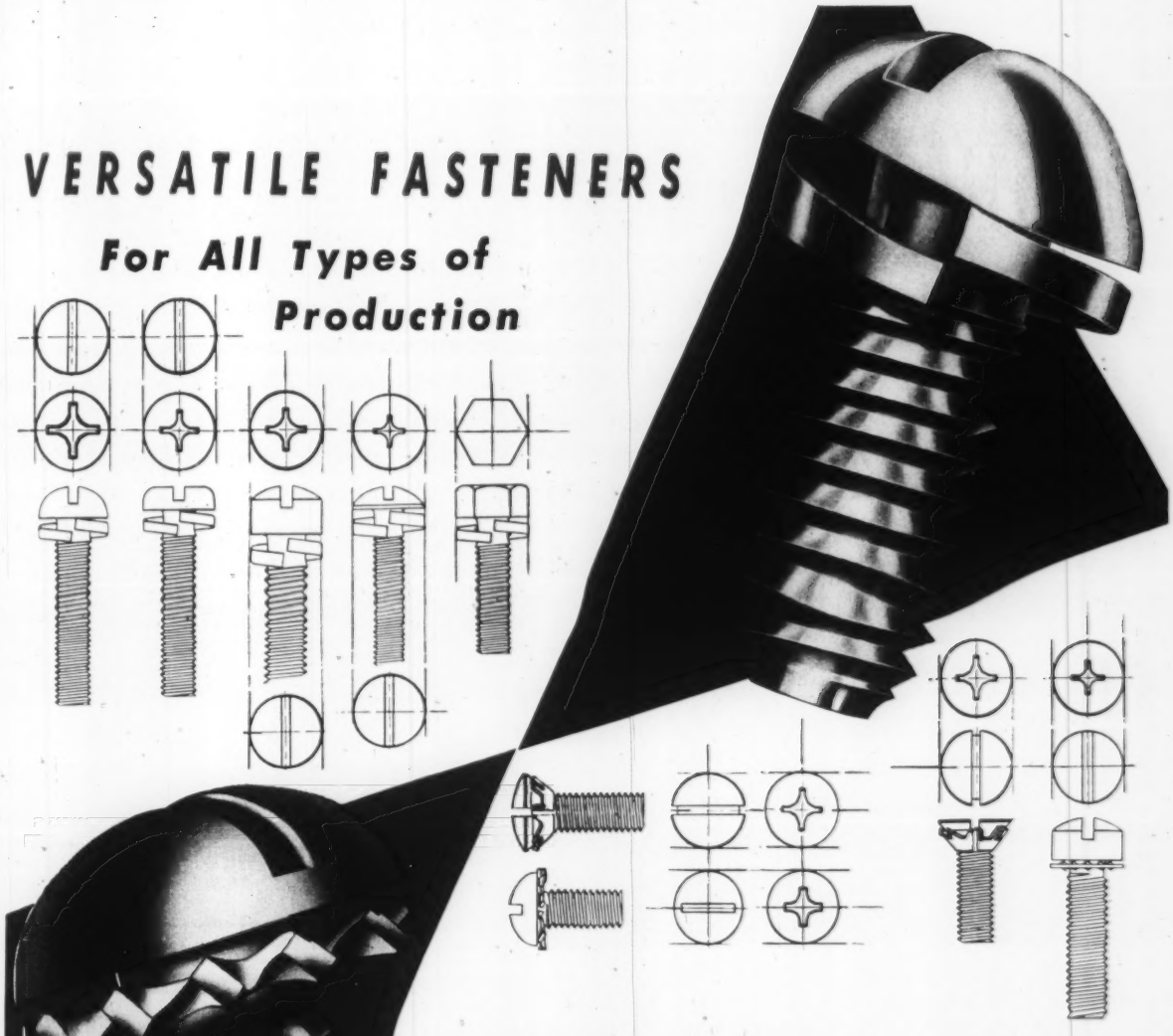
Prefabricated seals assembled to close tolerances minimize mounting difficulties with antifriction bearings. Thickness variations in the complete seal units are minimized by an assembly method in which seal dimensions can be maintained uniformly. Excessive



lubricant pressure is relieved by a specially shaped passage enclosed in the rotating seal and connected to the lubricant chamber by a series of holes. *Patent 2,708,125 assigned to Link-Belt Co. by J. M. Bryant and B. O. Richards.*

VERSATILE FASTENERS

For All Types of Production



EATON SPRINGTITES and SEMS

Eaton Springtites and Sems not only offer you the production advantages of pre-assembled bolts and lock washers, but give you a choice of heads best suited to your specific needs. The illustrations above show some of the varied types: round—fillister—pan—truss—hex. These head types are available with slot, Phillips and clutch recesses.

For the production man or designer, the right fastener for the job means faster assembly (can be hopper fed) and better end products. As with all Reliance fasteners, Eaton Springtites and Sems are under quality control supervision from raw material to finished product. Get the complete cost-saving story—write for Engineering Bulletin S-49 today.

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—ITEM 276—

"MONOBALL"

Self-Aligning Bearings

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CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

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—ITEM 278—

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460 WEST 34th ST. NEW YORK 1, N. Y.

—ITEM 279—

For More Information Circle Item Number on Yellow Card—page 19

WHAT IS THE PROPER AMOUNT OF TENSION TO APPLY TO A BELT?

Notwithstanding the many factors involved, it can be summed up in a few words as THE MINIMUM TENSION NECESSARY TO TRANSMIT THE REQUIRED POWER WITHOUT SLIPPAGE.

WHY THE MINIMUM?

Because more avails nothing, and EXCESSIVE STRESSES ON BELTS AND BEARINGS MATERIALLY SHORTENS THEIR LIFE.

The Proper Tension can be had, and maintenance reduced to a negligible quantity by mounting the motor on a Tension-Controlling

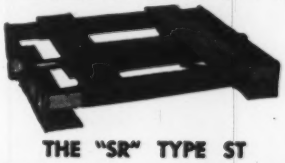
AUTOMATIC BASE. Micromatic adjustment for the Proper Amount of Tension is made while operating under load, merely by turning a screw. Not a bolt or nut is disturbed. Nothing could be simpler, and there is nothing more accurate.

The AUTOMATIC BASE can be mounted in any position, and the motor pulley may rotate in either direction.

WHY NOT PROVIDE THE "MISSING LINK" BETWEEN THE MOTOR AND YOUR MACHINE BY USING AN AUTOMATIC BASE?

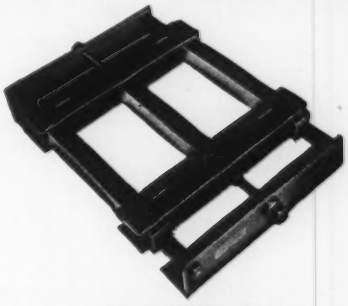
THE "SIMFLEX"

Provides Functional Utility at a Low Price. Made in two fractional sizes and for Old NEMA frames sizes 203 through 326.
Not recommended for use with motors having New NEMA frames.



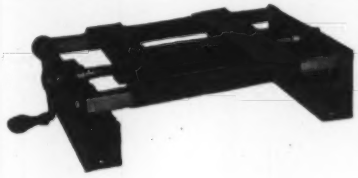
THE "SR" TYPE ST

A refined product made to close tolerances. The spring and working portion of the adjusting screw are enclosed and sealed in a grease-packed tube. The smooth walls of the motor carriage cooperate with close fitting square steel rails. Made in two fractional sizes, and for both Old and New NEMA frame sizes 182 through 326-U.



THE FLEXIBLE "BB"

The motor carriage rolls on linear ball bearings. All working parts are grease-packed and sealed. Stocked in four sizes for NEMA frames 364 through 505. Bases for larger motors, size unlimited, built to order.



THE "SR" TYPE SQ

For motors equipped with Variable-Pitch pulleys. The BASE with 'finger-tip' control at the crank handle.
Made in two fractional sizes, and for both Old and New NEMA frame sizes 182 through 326-U.

AUTOMATIC MOTOR BASE CO.
WINDSOR, N. J.

—ITEM 280—

Design Manual

"MECHANICAL ADJUSTABLE-SPEED DRIVES"

Parts I & II
by Leo F. Spector

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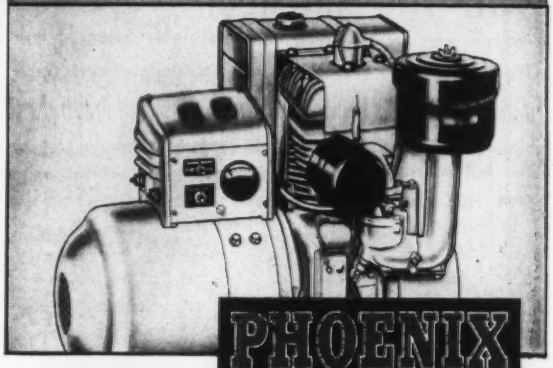

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by A. M. Wahl

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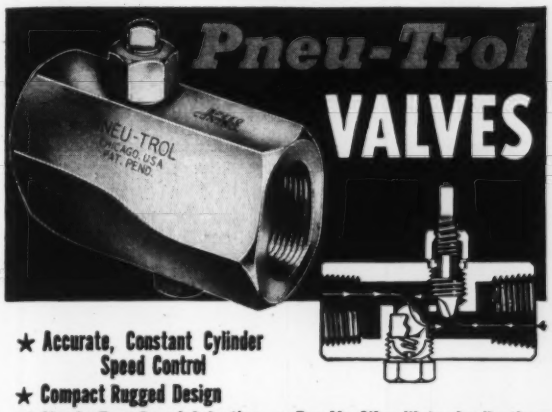
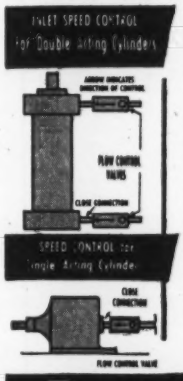


★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

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CADDY® TOGGLE CLAMPS
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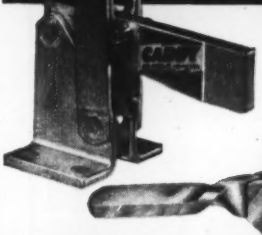
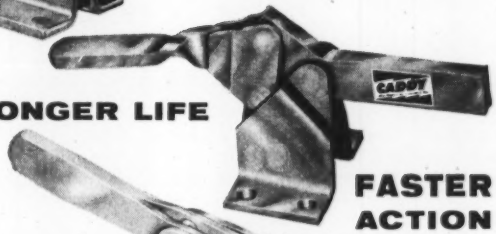


MORE PRESSURE



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CLEVELAND 3, OHIO

IN CANADA, ERICO INCORPORATED, 3571 Dundas St., West, Toronto 9, Ontario

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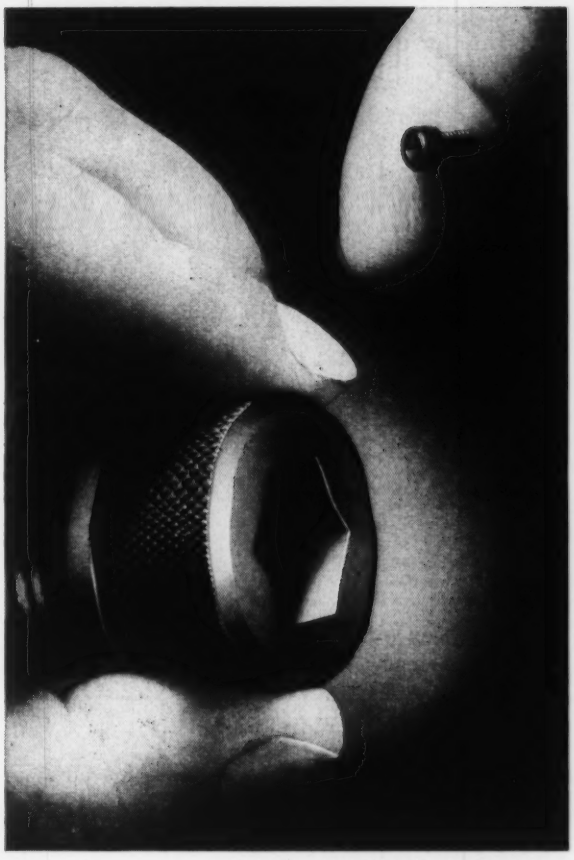

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Bristol Hex Socket Cap Screws mark your product "precision made"

The high quality and pleasing appearance of Bristol's Hex Socket Cap Screws will reflect the precision you've built into your product.

Perfectly squared-up heads and shoulders of these screws give them a smooth, accurate, and well-designed look. Their diamond-knurled heads make them easier to insert, to start and to spin up finger-tight. And, of course, they can be internally wrenched up permanently tight.

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Standard Bristol's Hex Socket Cap Screws conform to Class 3A fit. They're standard in stainless steel and heat-treated special alloy steel.

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Standard in sizes as small as No. 0 in Alloy Steel and Stainless Steel.

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

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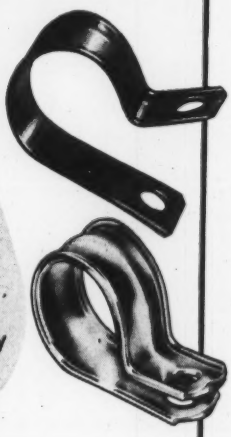
CABLE CLIPS



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of ethyl cellulose ...

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—ITEM 287—

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MOLYKOTE® LUBRICANTS

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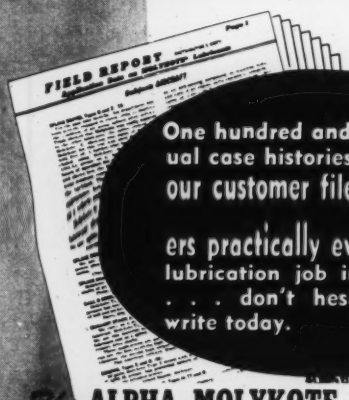

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Main factories:
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Please send me 10 pages of FIELD REPORTS
Name ..... Title .....
Company .....
Address .....
State .....

—ITEM 288—

ENGINEERS
AVAILABLE OR WANTED

WANTED: Engineering Executive. The Hohl Machine and Conveyor Company, Incorporated, a rapidly expanding Materials Handling Equipment Manufacturer, located in a newly modernized 36,000 square foot manufacturing plant in Buffalo, desires graduate engineer, age 35 to 40, as Assistant to the President. Must have machine design background and practical shop knowledge to take sole responsibility for all phases of engineering and manufacturing of special machinery and materials handling equipment. Ultimate goal with this position would be General Manager, in charge of Manufacturing and Engineering. Write direct with full particulars, including salary range and experience, to Hohl Machine and Conveyor Company, Inc., 1580 Niagara Street, Buffalo 13, New York.

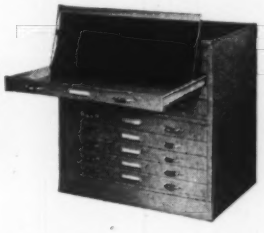
WANTED: Engineers—New Product Development. Ingenuity and initiative applied to New Product Development with a growing far-sighted company means progress for the experienced Electrical or Mechanical Engineers who are selected for these choice positions. Experience required in: Mechanical Design, Heat Transfer, Servo Mechanisms, Stress Analysis, Electro-Mechanical Devices. These positions offer an opportunity to grow in the fields of Atomic Power and Automation. Reliance Electric and Engineering Company, 1088 Ivanhoe Road, Cleveland 10, Ohio, Glenville 1-3538, Extension 570.

WANTED: Machine, Tool, and Product Designers. A national manufacturer located in the beautiful Shenandoah Valley, where living is at the best, needs several designers with M. E. degree, or equivalent, for small parts, high speed production. Steady work, high pay, and all benefits. Send resume to Box 890, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Chief Refrigeration Engineer, with extensive sheet metal and refrigeration experience to have charge of design engineering department medium size rated (A.A.-1) expanding company. Work location New York City with moderate traveling. Please send resume and include recent earnings to Box 959 Realservice Advertising, 110 West 34th Street, New York City.

MAYLINE

MAYLINE Metal Plan Files Intermember and Interlock!



All Mayline metal plan files intermember and interlock. Reinforced corners permit units to be stacked safely.

Drawers operate on ball bearing rollers and are equipped with attractive grey vinyl coated dust covers.

For information about stacking with files you now have, check dimensions shown in folder S-20, or write factory.

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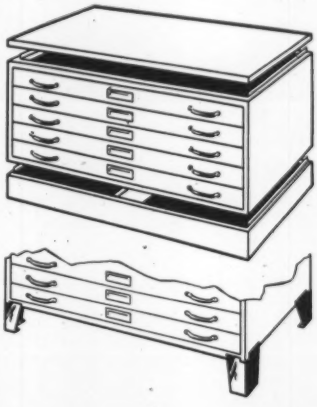

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—ITEM 289—

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—ITEM 290—

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many types and sizes

supplied from stock

to help motor makers

build better motors

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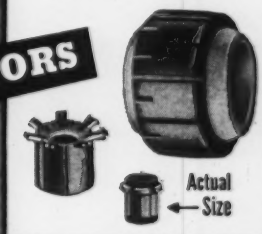

WITH or WITHOUT PRONGS

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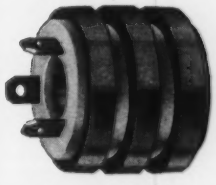

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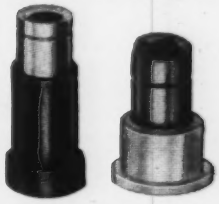

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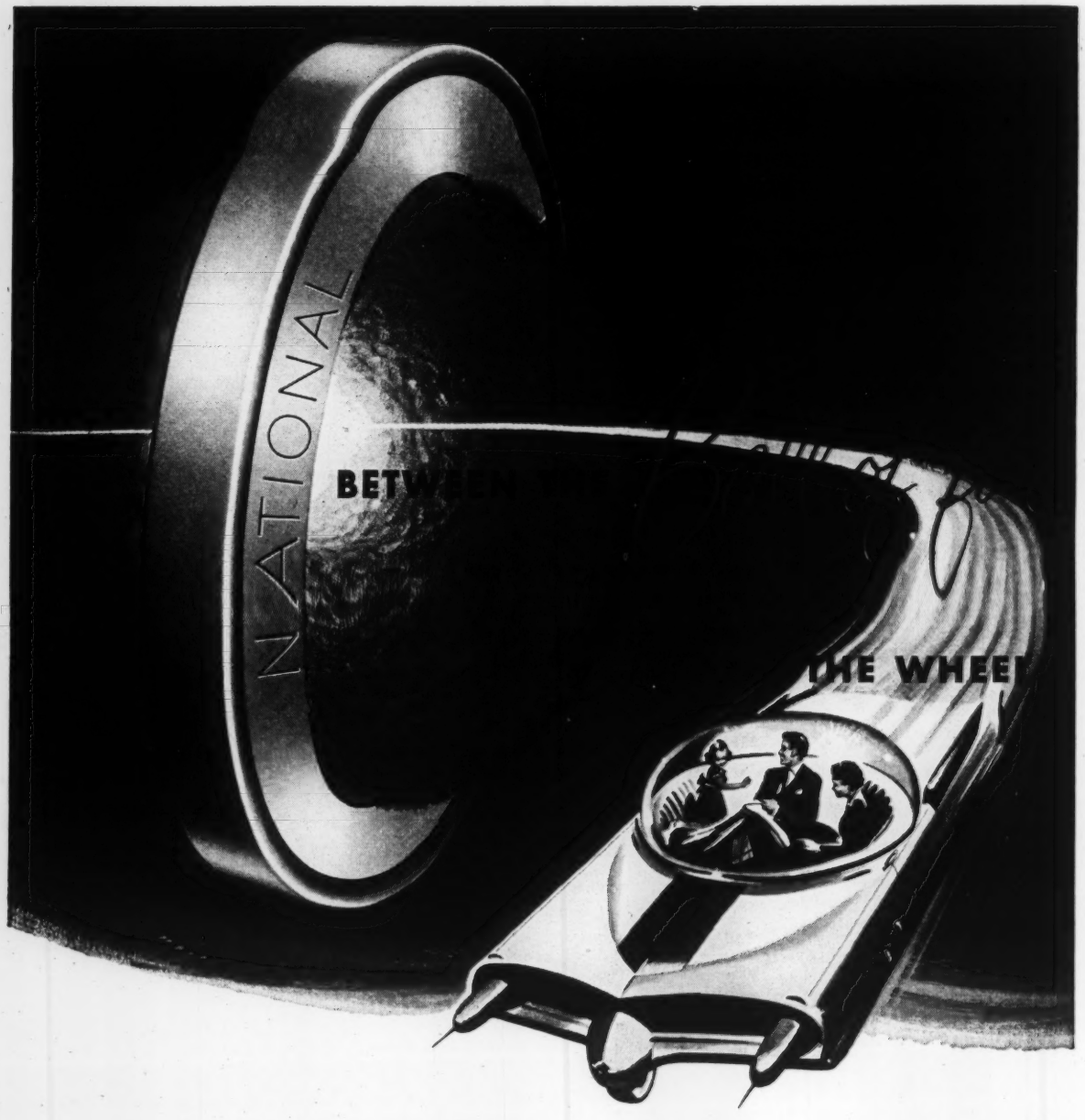

Motor cars of tomorrow will be swift and silent beyond belief, powered by the mightiest forces man can employ. Perhaps this power is nuclear, perhaps from a chemical fuel. From either will come the "release explosion"—a swirling "ball of fire"—pure energy to be contained, controlled, delivered to the wheels.

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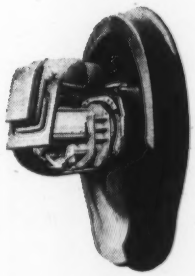

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NATIONAL OIL SEALS ®

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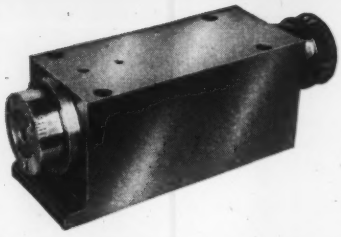
BPA NBP

LOOK AT THIS UP-TO-THE-MINUTE EXHIBIT OF

POPE PRECISION SPINDLES

EXHIBIT A

POPE SUPER-PRECISION, HEAVY DUTY BORING SPINDLES for boring holes round within millionths of an inch. Available in both belt driven and motorized units to meet a wide range of speeds and horsepower. Send us your specifications for quotations.



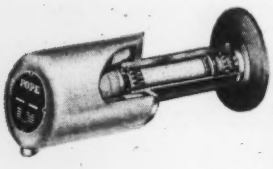
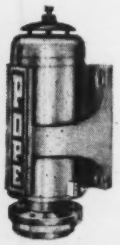


EXHIBIT B

POPE 1 HP, TOTALLY ENCLOSED 3600 RPM MOTORIZED, CARTRIDGE TYPE PRECISION SPINDLES with double row cylindrical roller bearings and separate thrust bearings for no endwise movement of the shaft.



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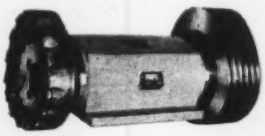
POPE HEAVY DUTY ¾ to 100 HP DIRECT MOTORIZED SPINDLES for Horizontal or Vertical Skin Milling, Grinding, Milling, Boring and Other Operations.

EXHIBIT D



POPE HEAVY DUTY VEE-BELT DRIVEN, PRECISION MILLING SPINDLES, and Wheel Heads, ½ to 50 HP.

EXHIBIT E

POPE INTERNAL GRINDING SPINDLES for Bryant, Excello, Heald and Landis Grinders.

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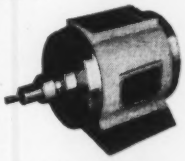
POPE SUPER-PRECISION HIGH FREQUENCY HEAVY DUTY GRINDING AND MILLING SPINDLES for speeds up to 100,000 RPM.



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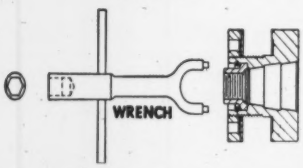

NEW **POPE** QUICK, SELF-REMOVING WHEEL HOLDER for surface grinders and tool and cutter grinders—eliminates the necessity of a wheel puller. Write for quotations.

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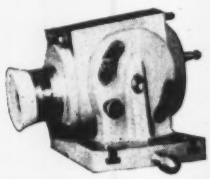

POPE SUPER-PRECISION MOTORIZED TOOL AND CUTTER GRINDER SPINDLES with clearance Angle Swiveling Heads for Angular Adjustment in A Vertical Plane.

WRITE FOR COMPLETE SPECIFICATIONS, PRICE AND DELIVERY

No. 107

Specify **POPE** PRECISION SPINDLES

POPE MACHINERY CORPORATION
Established 1920
261 RIVER STREET · HAVERHILL, MASSACHUSETTS

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DRIV-LOK STUDS

Save 60% Fastening Time!

- HOLD PERMANENTLY
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Quick, simple insertion . . . Drill Hole and Drive Stud with a single blow.

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Attaching name plates or instruction panels

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Widely used for fastening brackets.

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3 HEAD STYLES

Round (standard) — Flat (to order) — Countersunk (to order)

Driv-Lok Studs save time and reduce costs in fastening name plates, covers, brackets, panels, etc, to heavier sections and for countless other applications involving light-to-heavy member fastening. Once installed, Driv-Lok Studs will not vibrate loose or fall out—yet they can be easily removed without damage to components. Made in 3 head styles. Write for illustrated catalog sheet, prices and samples.

DRIV-LOK PIN COMPANY
715 Chauncey St. • Sycamore, Ill.

—ITEM 294—

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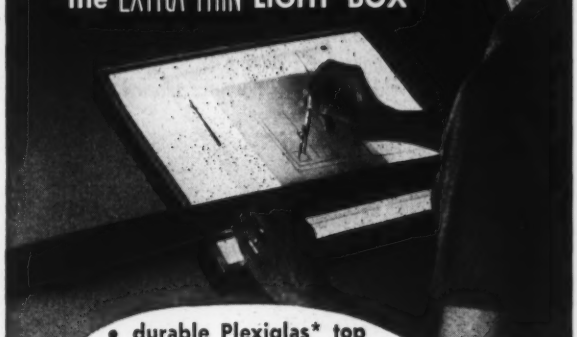
Porta-Trace®

the EXTRA THIN LIGHT BOX



- durable Plexiglas* top
- lifetime stainless frame
- cool fluorescent lighting

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Eliminates old fashioned, bulky tracing tables and units. Porta-Trace is ready to use in seconds! Only 1⅜" thick, it is convenient, easy to work on, and can be stored like a book when not in use. Perfect for any tracing job in drafting, layout, art, photography. And, Porta-Trace gives sufficient light to permit tracing on Bristol board! Model #1118-1, 11 x 18¼", $27.50. Available in sizes up to 24¼ x 36¼"; custom units can be built for special requirements. For complete information and price list, write today!

*Registered trademark of Rohm & Haas Co.

A. F. Gagne, Jr., Associates
11 Chestnut St., Binghamton, N. Y.

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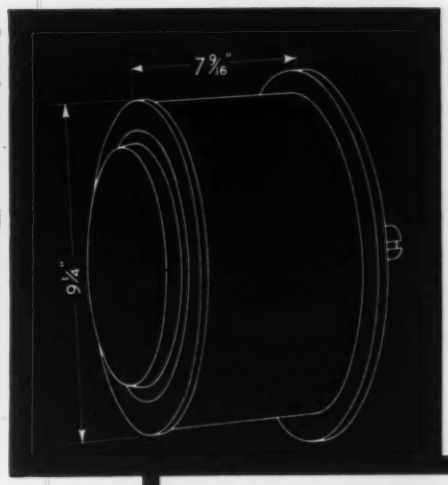

PANCAKE POWER

by Peerless®

● A machine tool manufacturer asked us to build him a motor with 1 HP; 1,750 RPM; single phase to fit a 7-11/16" space in the base of his lathes. This is the motor. It is totally enclosed to seal out the dust and chips encountered under shop conditions. The motor answers the requirements in every respect and gives him top product performance.

Peerless Electric develops hundreds of motors for OEM use. Let us tackle your motor problem. Peerless teamwork engineering—our engineers working with your engineers — will produce the one motor that powers your products best.

ELECTRIC MOTOR DIVISION
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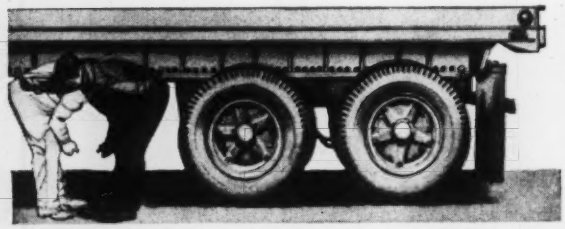
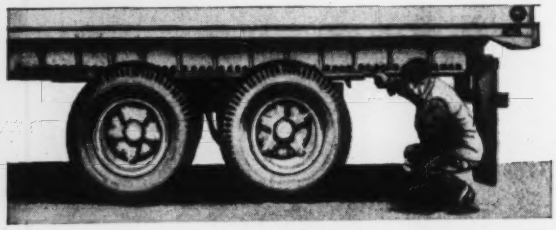
1520 W. MARKET ST. • WARREN, OHIO

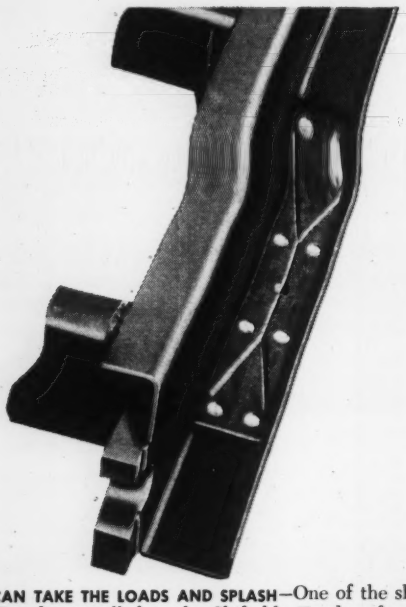
—ITEM 296—

Wrought Everdur* Cuts Cost in Half



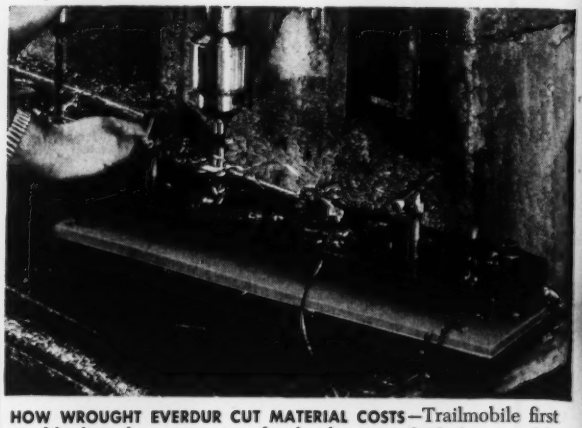
THE TRAILMOBILE SHIFTABLE TANDEM—Truckers often lose time and money in shifting trailer cargo, changing tractors, or cutting payload to meet legal axle-weight requirements. Now, however, they can balance any load in just five minutes by moving the Shiftable Tandem Axle Assembly made by Trailmobile Inc., Cincinnati, Ohio. The axle assembly slides forward or backward, as needed, along a stainless steel rail on four shoes of wrought Everdur. It can move 66 inches and be locked at 3-inch intervals by locking rods through holes in the rail.



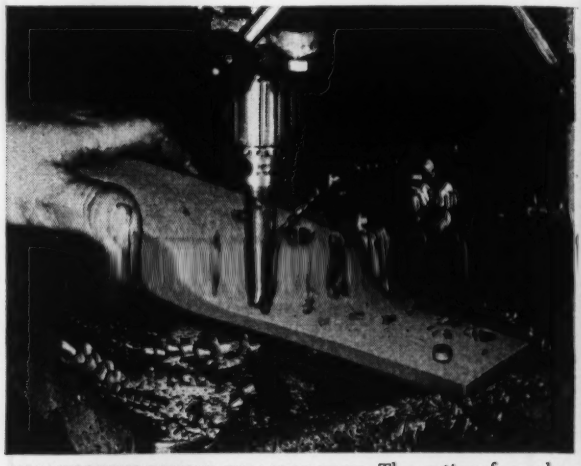


EVERDUR CAN TAKE THE LOADS AND SPLASH—One of the shoes of wrought Everdur installed in the Shiftable Tandem frame. An Alemite fitting in center hole and oil grooves provide lubrication. The Everdur shoes carry normal tandem loads of 32,000 pounds day and night, and slide freely under this pressure. Resistance to corrosion is another reason why Everdur was selected, for unlike the trailer's cargo, the Everdur shoes are exposed to road splash of varied mixtures.

Wherever metal must resist corrosion, be strong and tough, and be available in forms easily fabricated, consider Everdur, Anaconda's family of copper-silicon alloys. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. *Reg. U.S. Pat. Off. 5661



HOW WROUGHT EVERDUR CUT MATERIAL COSTS—Trailmobile first tried high-tin bronze castings for the shoes on which the assembly slides. But rejects for porosity and warpage in the thin cast section were a costly problem—and all surfaces had to be finish-machined. The wrought Everdur bar stock suggested by Anaconda's technical experts has surfaces satisfactory as delivered—ready for drilling holes (shown above).

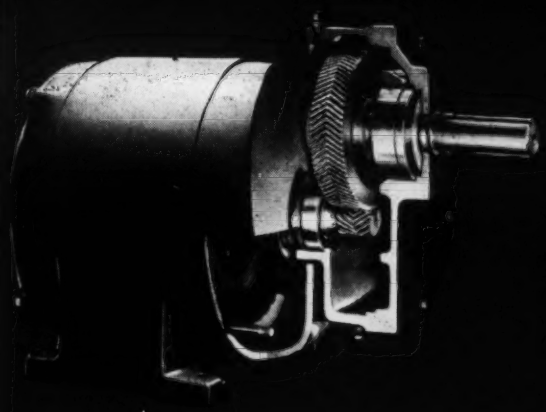


HOW WROUGHT EVERDUR CUT LABOR COSTS—The castings formerly used were not uniform. Hard spots made surface machining difficult and expensive. The entire operation was unnecessary with wrought Everdur bar stock—reducing labor cost by about 50 per cent. (Above) Countersinking holes for screw fastenings.

WROUGHT EVERDUR IS READILY MACHINABLE—Though tough and dense, wrought Everdur is uniform and poses no special problems in machining. Oil grooves are shown being milled in the shoes.

EVERDUR

ANACONDA® COPPER-SILICON ALLOYS



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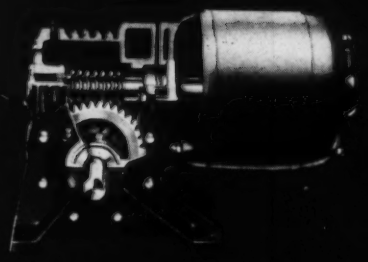

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